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TO OUR CONTRIBUTORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum for exchange of experience in science education and science projects.

Articles covering these aims and objectives are invited.

Manuscripts, including legends for illustrations, charts, graphs, etc. should be neatly typed, double spaced on uniformly sized paper, and sent to the Editor, **School Science**, Department of Science Education, NIE Buildings, Sri Aurobindo Marg, New Delhi 16. Each article may not normally exceed 10 typed pages.

The articles sent for publication should be exclusive for this journal. Digests of previously published articles modified to suit the scope and purpose of **School Science** will be accepted. In these cases the name of the journal in which the original article appeared must be stated.

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Selected references to literature arranged alphabetically according to the author's name may be given at the end of the article, wherever possible. Each reference should contain the name of the author (with initials), the title of the publication, the name of the publisher, the place of publication, the volume and page numbers.

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Editorial

WE ARE LIVING in the midst of a mighty explosion—the explosion of scientific knowledge or science explosion. The present generation is already engaged in tackling the problems of the nuclear explosion and the population explosion. The success achieved in these fronts is due to the awareness not only of the scientists but also of the statesmen, social philosophers and the common people. But, have we tried to understand the nature and consequence of the tremendous scientific activities in modern times ?

On many counts, the scientific explosion is more 'violent' than the population explosion. The number of working scientists living today far exceeds the number of scientists that ever lived. The 'doubling period' for the world population is not less than hundred years, whereas the 'doubling period' of science is only ten to fifteen years. That means the number of scientific workers, the amount of budgetary investments, the number of research publications are doubling every ten to fifteen years.

Undoubtedly, the fast expansion of scientific activity is highly desirable. Advanced, science-based technology would enable us to provide food and shelter for all. The growth of science and technology is essential to meet the challenge of disease, overpopulation, pollution and to conserve the dwindling natural resources. Our awareness of the nature of scientific development would help us orientate our thinking to a better planning of science, society and intellectual activities.

But, the treasure of scientific knowledge is already so vast that it is impossible even for a scientific genius to acquire a moderate expertise in contemporary science as a whole. And it is neither possible nor desirable for a working scientist to try that. Intensive scientific research is the domain of the specialists. With the accelerating rate of scientific growth, the specialists are compelled to restrict themselves to narrow fields. Many specialists have become precariously narrow. In the process, their own thinking have gradually become impoverished. They have often been vulnerable to political power and the lure of money.

Progress of different branches of science is interdependent. Science has always advanced through apparently two different tendencies : specialization and synthesis. These are not mutually antagonistic. In fact, every successful scientist, whether a generalist or a specialist, ought to be a little of both. If this trend of over-specialisation is not checked, it will transform different fields of science into incommunicable mysteries, where generalization will no more be possible.

On the other hand, the modern society is increasingly being split into two cultural groups : the arts and humanities (literary intellectuals, philosophers, artists, sociologists etc.), and the sciences (physicists, chemists, biologists, etc). Between these two poles is growing a gap of mutual incomprehension. They have started forming strangely distorted images of each other. The rupture has even touched the emotional sphere.

This polarization is dangerous. After all, science is only the most recent of the three major stages in the development of human skill. The arts and the humanities are its predecessors. The arts are the skill of the individual (speech, the use of weapons and tools, painting, music and dance); the humanities are the skill of community living (reading and writing, accounting, the skills of law and government); and the sciences are the ability to control the environment effectively. This is only a gross approximation of the broad events. Neither their definitions are precise nor their courses of development so crudely exclusive. During every stage of development, the other elements had always played their roles, though only in a subordinate way.

Each of these successive elements could flourish only when the objective preconditions were set by the interaction of the earlier developments. These major developments are by no means three separate cultures. These are only like three broad tributaries of a river, which have combined in additive fashion to shape the modern human culture. In course of time, the arts and the humanities have almost completely merged. But the integration of science still remains to be achieved. Science cannot flourish without the conscious support of the community skill or the individual skill.

In the early stages of growth of science, the cultural split was not so apparent, because the writers of those times (including scientists) tried to make science understandable to the reading public. Perhaps science was comparatively simple and were read by well educated men only. The gap became wider during the last century as a result of scientific findings of a complex nature. But probably the main factor that impaired the integration is the ignorance of the society of the revolutionary nature and consequence of the scientific developments (during the Renaissance) and the industrial revolution that followed later. The industrial revolution crept on without the society's taking conscious notice of its impact, that is, the biggest qualitative changes in the social living the civilization has ever known since the adoption of agriculture. This development was looked down upon with doubt and dislike. The conflict between science and the traditional culture flared up violently. Even great intellectuals took sides and fervently debated for one or the other element.

Warnings, against a 'fractured culture' have also continued in cycles since the Victorian era. Efforts have been made to present the significant scientific discoveries to the people in simpler ways. The teaching of science was gradually introduced as a part of general education. Though the breach could not be bridged completely, the conviction has grown that the polarization is absolutely artificial and meaningless. It has affected the quality and progress of all the streams of our culture: the arts, humanities and the sciences.

Back to 'science explosion' or 'techno-scientific explosion'. The present phase of science is dated to the second decade (large-scale chemical industries) or the fourth decade (practical use of atomic particles) of this century. Characterized by electronics, atomic energy and automation, it is basically different from the earlier phase of science. This change comes from the conscious use of science in industry, devoid of any chance factor. Now, not the ideas of odd inventors but a real planned development nurtures it. It is far more deeply scientific and far reaching in its result.

This is likely to transform our philosophical premises, production relations in the society and the fundamental basis of our civilization. Can the society in general keep intellectually aloof from this development ? Can it afford to be ignorant of the interplay of its own creations ? Can it be left to the narrow specialists of science to control our affairs entirely ? Or, is it not equally dangerous to allow any group of non-scientists, politicians, statesmen, economists or sociologists, unaware of its nature and impact, to decide the future of mankind ? Should we not close the gap between the knowledge explosion and the common people so that the affairs can be managed by the socially conscious scientists and scientifically orientated social philosophers and statesmen ?

How to achieve this ? The mutual hostility is deep and diffused, and runs in individual lines. And their integration, however, is not possible to achieve through a formal 'treaty'. The answer undoubtedly lies in the structure, composition and implementation of the educational system.

India has long been an underdeveloped country with stagnating traditions. This problem of dichotomy is rather new in Indian society. With the scientific and industrial development, after independence, we have also been caught in a conflict of another kind: between the static traditions and the dynamism of modern science. The West became acclimatized to the old industrial revolution and scientific thinking during the last four centuries. In India, developments will obviously be quicker because the course of the older industrial revolution and the new techno-scientific achievements are likely to be telescoped. All the traditional elements in individual and social thinking, daily life of the community, means of production and their relations to the society have to be readjusted to absorb the violent shake-up. For the last few years we have been trying to develop a uniform pattern of education for the whole country. Several states have started implementing curricula with 'science for all' at the secondary school stage. It also means 'arts and humanities for all'. The objective obviously is not to make every student a scientist. The curriculum intends to impart a broad understanding of the essential unity of human culture and the role of science in it.

The history of science will show how many of the great scientific ideas came from the non-specialist geniuses in different ages. Leonardo da Vinci, for instance, was not only one of the greatest painters that Europe ever produced, he was also famous for his scientific observation, engineering skills, town planning and architecture. Science has passed through four hundred years since the time of Leonardo.

We know that, in today's context, it is not possible to have great versatile geniuses like Leonardo or Aristotle. Yet, from the lives and works of modern scientists like Albert Einstein, Bertrand Russell, Robert Oppenheimer, Julian Huxley or J. B. S. Haldane, one can appreciate their broad-based understanding of the sciences and the arts.

The new structuring of science education at school should aims at this broad base, or, to put it in another way, the Renaissance versatility. □

Man—The Destroyer

KALYANI G. MENON

School of Life Sciences
Jawaharlal Nehru University
New Delhi

MAN—WHO PROUDLY NAMED HIMSELF *Homo sapiens*—has always considered himself most closely akin to the Great Creator He has always been placed at the top of an inevitable evolutionary spiral. Yet, for the non-primate animal world, the evolution of man may have been the worst piece of luck they ever suffered. In his short span of existence on the earth, man has been directly responsible for the extinction of more than 400 species of animals. In spite of massive propaganda by international societies, and desperate measures by Wildlife Conservation Boards, each year, as regular as clockwork, one species of bird and one species of mammal become extinct—a rate of disappearance far higher than at the times of the greatest geologic crises before man arrived on the scene. Directly because of man, the world has lost 110 mammals since the birth of Christ. Since 1669 (when the last dodo died) 162 species and sub-species of birds have been exterminated. Zoologists estimate that there are at least 78 more species which will become extinct before 2,000 A D. These include the grizzly bear (a favourite target for American hunters), the black-footed ferret (which feeds on the rapidly disappearing prairie dog), the ivory billed woodpecker, the maned wolf, the spanish lynx, the Indian lion and the Javan tiger (of which there are only ten left alive).

The West, in spite of Christianity and Darwin has considered man a thing apart from the rest of nature. This has fostered the idea in man that nature has no reason for existence except to serve him. As a consequence we have the present waste of the world's environment. In constrast to this attitude, was the humane doctrine of Buddhism, fostered in India by the Emperor Asoka. His edict of 300 B.C. forbidding the killing of wild animals except for food, and even then only at certain times of the year, is the first recorded instance of a policy of wildlife conservation. India, until recently, had not exterminated a single mammal, although the white tiger is now in danger.

What is it in man's psychology that makes him such a heedless destroyer ? The least guilty motive is carelessness. Thus, the flightless bird, the dodo, was quickly wiped out by the pigs, dogs and cats introduced by the settlers of the Mascarene Islands. In 1918, a shipwreck left rats on Lord Howe Island near Australia, which until that time was a unique bird paradise. In fifty years, the rats had completely exterminated five species of native birds. The same events took place on the island of Herekopare in the Pacific, when cats brought in by European settlers took to the wild and destroyed more than seven species of birds. In several Pacific islands, the mere appearance of man in a colony of birds such as the spoonbill, has been enough to make them desert their nests permanently. When the dog was introduced into Australia, it reverted to the wild state and became the Dingo, a fierce hunter which competed for the same prey as the marsupial wolf and the Tasmanian Devil. These animals are now reduced to small groups in Tasmania, where there are no Dingos. Competition between the Ring-necked pheasant, introduced from Asia, and the prairie chicken of N. America, has resulted in the near-extinction of the latter.

A species may be equally efficiently destroyed by destruction of its habitat. The clearing of large forests of redwood trees in America is eliminating the rare red-headed woodpecker. The black rhinoceros is rapidly disappearing in Africa as the bush country, its natural home, is fast becoming dry grassland as a result of drought and fires. The African elephant is similarly threatened. The Masai tribesmen, originally hunters, were encouraged by European rulers to turn farmers, and their farming and ranching are disrupting the migratory patterns and hence the breeding of huge herds of grazing animals.

In many cases, man deliberately sets out to destroy some unfortunate creature which, he claims, does damage to his stock or devours his crops. None of us will ever see the passenger pigeon, a bird of which at one time there were more than 30 billion in North America. One flock was estimated at 2 billion and its breeding ground covered 800 square miles. Farmers hated these birds, and shot them in huge numbers. At the last great commercial hunt, in 1889, fifteen tons of birds were killed (the numbers were too huge for the hunters to estimate). Like many other flocking-bird species, the passenger pigeon needed a certain minimum number to survive at all, and when their number fell below this threshold, they collapsed. The last of them, a bird called Marths, a captive in a Cincinnati zoo, died on 1 September 1974. Not satisfied with this, American ranchers are now trying to eliminate the coyote by the wholesale use of cyanide bait supplied by a government agency. Nearly 100,000 coyotes were killed in 1967.

The gentle female of our species is solely responsible for the implacable slaughter of many harmless and beautiful furbearing animals. My lady must have her fur coat, and so the friendly and inquisitive sea otter—easy to kill with a blow on the head as it swims up to the boat—and the gentle fur seal, has been chased to the very brink of extinction. The most senseless murder is that of the seal pups. A seal mother will not nurse a strange pup, so once the mothers are killed, the Alasken beaches are littered with the small bodies of pups which have starved to death. The booming trade in feline furs has resulted, almost overnight, in the near-extinction of the lynx (a somewhat stupid animal which can never learn to avoid traps), the leopard, the cheetah, the jaguar and the tiger. Because their skin makes beautiful leather for handbags and shoes, the alligator, the crocodile and the wart snake are on their way to utter extinction. The bird of paradise, the egret and the roseate spoonbill were nearly wiped out because their feathers appealed to feminine tastes.

The mass killing of animals, first for food or later because of mere blood-lust, is a part of human history. The list here is long and tragic. The majestic ostrich-like moas of New Zealand survived until the Polynesian immigrants arrived in 1350 and began hunting them for food. The world's largest bird, the elephant bird, lived in huge colonies in Madagascar, and were easily consumed by the Malayans. The North American bison, at one time estimated to have a population of 60 million, was slaughtered for sport, the carcasses often not even being touched, until now there are only 500 left. The musk-ox, a surviver from the preglacial past lived in Greenland until Western settlers supplied the eskimos with high-powered rifles. The shy, noble old animal was a victim of an orgy of killing. One of the most beautiful antelopes, the Arabian onyx, has been shot out of its native habitat by Arab princes pursuing it in their Cadillacs. Wallabies were poisoned by Tasmanian settlers who feared it would endanger their sheep pasture. In Colombia, the Capybara, the world's largest rodent, is being hunted ruthlessly for its meat. They are herded by the thousands into corrals and clubbed to death.

The most inevitably doomed of the food animals are the large tortoises and turtles. The Galapagos tortoise, the marine turtle and the green turtle are all moving slowly towards extinction. In other kinds of sea food, the harvesting has become so intensive and competitive that there is a likelihood that even the inexhaustible ocean will give out before the end of the century. The point of overkill—when colonies fall below the number required for breeding—may have already been reached for the lobsters, oysters, sardines and whales. Denmark is responsible for the deliberate and senseless extinction of the Atlantic salmon; by netting of young and breeding fish from their summer feeding grounds.

Another terrible reason for the near-extinction of several species and the alarming lowering of the rate of reproduction of countless others, is the careless and continued use by man of chlorinated hydrocarbon insecticides such as DDT. The golden eagle, the bald eagle and the Bermuda petrel, are definitely being destroyed and will disappear in a few years. Once ingested, DDT is concentrated in the fatty tissues and passed on from member to member of the food chain, causing death by degeneration of the nerves and by making the eggshells too fragile to survive the laying process.

How much longer can the list be ? The great African mammals are victims of the hunters, as are the huge herds of deer which roamed the European forests as little as 100 years ago. Laws have been passed, but determined poachers make no bones about breaking them, and making a princely living in the process. The International Wildlife Conservation Commission is struggling against lack of funds and public apathy.

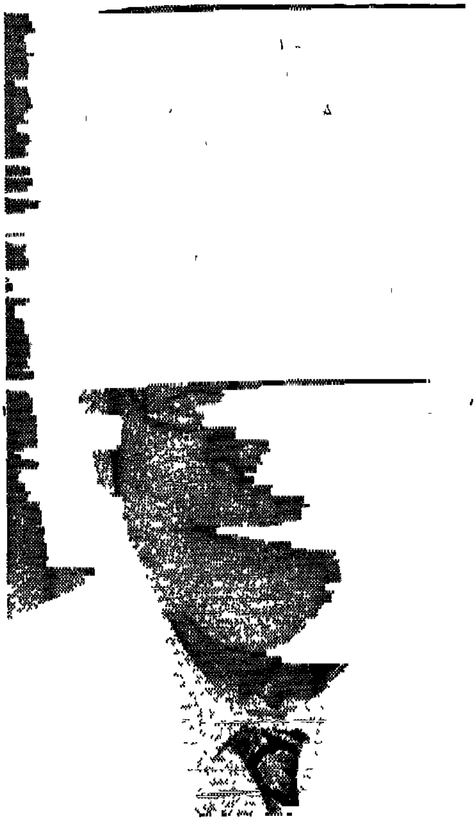
It is interesting to speculate on how the animal kingdom as a whole would have fared if man had never evolved. Yet there is hope. Happily, this animal, man, is capable of social evolution. Although he has wiped many animals off the globe for all eternity, it is possible that he will devote his ability and intelligence to saving those that are left, and will learn to share the environment with them. ☐

Julian Huxley : A Profile

Utpal Mallik

Lecturer, Department of Education in Science and Mathematics, NCERT, New Delhi

It is far from easy to justify one's own self when one is born a Huxley, and that too, as a grandson of T.H. Huxley. While a remarkable heritage is an enviable privilege, it has its dwarfing effects on a man of ordinary proportions. Few people can deny these effects and very few have done so more successfully than Sir Julian Sorell Huxley, FRS—a profile that you could enlarge a hundred times, and still larger—to gigantic dimensions. Certainly it was in the life of Julian that the Huxley characters had been amply revealed and it was in his achievements that the point counter-point of science and philosophy most strikingly displayed. But very often Sir Julian's own ambivalence came to the fore. He knew he was singularly outstanding and able, yet he could not always believe that he was really worthy of the recognitions he had received: often he thought that it was because he was THH's grandson. But much of this ambivalence was rather injustice to himself. He excelled not in one but almost in every path of human endeavour, and this chiefly by means of a quality of character: non-conformity and individuality. This is borne out by THH's remark about Julian, "I like that chap. I like the way he looks you straight in the face and disobeys you".



JULIAN HUXLEY
(1887-1975)

Biologist he certainly was, and that too, cast in the classic mould. But that is not the whole truth, for Sir Julian was, at once, a poet, a humanist, a classroom teacher and a philosopher. In his own modest words, he is not to be remembered "primarily for...specialised scientific work, but as a generalist; one to whom...nothing human and nothing in external nature was alien".

Julian Huxley was born in a mid-summer night of 1887 when the city of London was celebrating Queen Victoria's Jubilee. His father Leonard Huxley, an authentic product of English peerage, was the second son of THH.

Photo : British Council

Like most other children, Julian became interested in nature study. Taken for a walk at the age of four, he was wonderstruck at the sight of a toad. "What a creature", he remembered later, "with its warty skin, its big bulging eyes and its awkward movements", and then again "that comic toad helped to determine my career as a scientific naturalist."

We pause here a while to test the soil he had grown in to maturity.

At the climax of the Empire, the Edwardian England was moving fast. Here was the fateful union of two tides—one, of the traditional, elitist, aristocratic England and the other of the England of mass education, almost universal literacy and middle class socialism. And out of the contrast between "the dark satanic mines" and the self-indulgent life of elegance and refinement were born the powerful voices of English intellectual life. The achievements of the doctors and scientists were outstanding. Great advances in surgery were made by Lister; Sir Ronald Ross discovered that malaria was carried by the mosquito. Bayliss and Starling defined the 'hormones'. Even more far-reaching, the investigations of Sir J.J. Thomson had revealed the existence of the electrons. By 1911, Rutherford had proved that the atom, far from being the dense irreducible basis of matter, was in reality a void where negative and positive charges of energy neutralized each other. On the other hand, there were the plays of Shaw, the novels and fictions of Wells, the statues of Epstien, the paintings of Fry, morals of Strachy and socialism of the Webbs.

In this atmosphere of silent turbulence of social, political and scientific currents and intellectual explosion grew up the young Julian, with all his Huxley ethos. If the Edwardian England had left any mark on his future profile, it was precisely on his intellectual versatility.

With his distinguished undergraduate record from Eton and later from Oxford, Julian Huxley began his professional career as a scientific naturalist while holding a lecturership at Balliol and a poorly paid demonstratorship in the Department of Zoology at Oxford.

The story of a man who lived a ripe and fruitful life of 88 years and strode on every path of human knowledge is almost an epic. Space does not permit me to cover the wide span of his intellectual territory. "For minds like mine", he related later, "in a civilisation like ours, the only salvation must include constant work and activity". During the mid-twenties he came into a position from where he could devote a great deal of his time to disseminate his own ideas as a writer and a speaker.

He had no looming problem of leisure. The lecturer of the Balliol became professor of the King's College and then of the Royal Institute, with intervening periods of minor appointments at home and abroad. In 1935 came an altogether different type of call; his life-long interest in the animal kingdom led him to the chair of the Secretary of the London Zoo. Undoubtedly, he was one of the very few academically equipped for the post. His knowledge of biology, enthusiasm for popular exposition and a diplomatic ability to satisfy the holiday crowd who line up at the Zoo left a mark of his stimulating presence in the Zoo for seven years.

The War broke out in Europe. Britain was spending most of the evenings behind the black-out. The BBC introduced a new programme, the Brains Trust, led by a battery of eminent intellectuals and Huxley was one of them. The Brains Trust programme was a fabulous success, answering numerous interesting and socially relevant questions asked by the listeners. Huxley became a national figure, known to a wider audience to whom he now represented the voice of science.

However, in 1942, Julian left the zoo cage and found himself back in the position he had occupied so long—a freelance scientist and writer. Now the war claimed more from Huxley. He wrote extensively and ceaselessly on the question of racial problem. His survey of the problem had been unique and scholarly. In extraordinary details he outlined how the Nazi theories of *Herrenvolk*, a superior race, had already blurred the prospect of science in Germany. Simultaneously, he produced during the same time, his greatest feat of scholarship—*Evolution: The Modern Synthesis*—the first comprehensive analysis of biological evolution as a process.

The war had ended. The plans for a United Nations Organization gathered details. The Unesco was born and Julian Huxley became its first Director General. The period of genesis of Unesco has rightly been called the 'Huxley age' of the organization. With lucid candour he worked out the philosophy of Unesco. "Few organisations follow more closely the Huxley line of thought than one linking the science and the humanities, adopting an international stance, taking a synoptic view, pledged to help all mankind 'without distinction of race, sex, language or religion'..." Towards the end of 1948, Huxley left Unesco—now a flourishing organization.

Honours succeeded honours. The Kalinga Prize, 'for distinguished popular writing in science'; Darwin Medal of the Royal Society, 'for distinguished contributions to the study and theory of evolution'; Darwin-Wallace Commemorative Medal. Knighthood followed in 1958.

One could resolve two components in his exploits on the battlefields of science. One major field of contribution, undoubtedly, was experimental biology. His study of the courtship behaviour of grebes and the private life of gannets are a landmark in the ethological study of birds. These studies on the avian courtship in relation to Darwin's theory of sexual selection were not only outstanding, what is more, they made the field of natural history scientifically respectable. His contributions to the study of the problems of relative growth and experimental embryology firmly secured his reputation as an experimental biologist. Yet, his greatest work might well have been his development of the Neo-Darwinian theory of evolution, achieved by his ability to see the connection between the widely separated branches of biology and binding them into a single evolutionary thesis.

The other field of contribution, of no less scientific value, was his crusade against spurious ideas in the field of science and against the pseudoscientific concepts. His lone stance against Lysenkoism was an example.

Biology certainly was there at the centre of Huxley's world. But he took biology as a link not merely between matter and mind but also between humanities and science. Professor Huxley's humanism reflected his deep insight into the trinity of religion, man and destiny. Beyond scientific scepticism, the philosopher affirms a humanistic faith based on man, his intelligence and his scientific method. Man is as much a natural phenomenon as an animal. His frame, mind and soul were not supernaturally created. They are evolutionary products. The humanist proposes a faith based on man's ability to reason to seek the truth, to realise his innate potentialities. Man alone can alter his own future, for better or worse. The humanist's views embody the facts and principles of evolutionary humanism. Today's is the crisis of convergence—a convergence of nations, cultures and populations, of ideas and values. The humanist pleads for a reconciliation of all this into some renascent philosophical approach, integrated into some new evolutionary and humanist system.

Sir Julian passed away (14 February 1975).

The glittering honours were but the fitting recognition of his life's work. The lustre and respect which lighted his evening path were a measure of the services he rendered towards science, society and humanism. ☐

Heat Conduction and Steady State : An Experiment in Teaching through Demonstrations

M.V. ANANTHAKRISHNAN
National Institute of Foundry and Forge Technology, Hatia, Ranchi

THE PRESENT EDUCATIONAL SYSTEM FOLLOW THE under-mentioned approach :

(a) Completion of a specified syllabus by the teachers concerned and that too from an examination point of view.

(b) Dictation of voluminous notes (in some cases) and solution of stereotyped problems which in many cases are direct applications of formulae.

However, the above approach does not contribute significantly to the "learning" process. This is mainly due to :

(i) Absence of project work allotment in regular courses (with some exceptions, of course).

(ii) Stereotyped experiments requiring only an observation of meters and gauges and verification of established physical laws. The latter is done by verification on the basis of observed data rather than by trying to arrive at a relation on the basis of observed data.

Thus, considering the facts outlined above, the "creative" teaching can be practised only in courses where the student performance in examination is not the principal criterion. As such, the training institutions (conducting short-term refresher courses) and autonomous bodies have a great scope to take a lead in this direction.

THE EXPERIMENTAL STUDY

Taking the typical example of "heat conduction", here the author has attempted to impress as to how we can improve the learning process. This is an outcome of the physics teaching by the author during 1966-1973. An important concept to be highlighted here is the close coordination needed between the theory lectures and the corresponding practical classes.

The equation of interest in the discussion on heat conduction (under steady state conditions) is :

$$Q=\frac{KA\,(\theta_2-\theta_1)}{d}\ \text{cal/°C/sec/cm}$$

Where Q = rate of heat flow along a rod of length "d", area of cross section "A", and whose thermal conductivity is "K". θ_2 and θ_1 are the temperatures at the hot and cold ends of the rod respectively.

Once the teacher presents the above equation, the following questions are quite natural :

The author wishes to thank the Director, NIFFT, for providing facilities to carry out the present experiment, and Mr. K.A. Reynolds, F.I.M., Open University (U.K.), for introducing him to the fascinating field of educational technology.

(a) What is the process of heat conduction ?

(b) What is steady state ?

A series of following demonstrations to explain the above two queries will be in order.

Demonstration I

This has reference to query (a)

A number of empty cigarette cartons are arranged equispaced in a straight line. When the carton at one of the extremities is given a slight tap with the finger, one will notice that all the cartons will fall down in sequence. This demonstration, to start with, has acted as a "stimulant".

Now, let us analyse the outcome. Whilst some of the intelligent students would have been successful in learning through this experiment, a majority of the students would need some more initiation into the concept. The teacher now steps in and compares the cartons (arranged in a line) to the atoms regularly arranged in a solid and mentions that heat is a form of energy. This is all that is needed for the students to have an elementary concept of heat conduction mechanism. The students have thus been able to learn (at their own pace) that in the conduction mechanism, the atoms do not drift along the direction of heat flow, but the energy is transferred from one atom to another (from the hot end to the cold). This explanation may still be unable to whet the appetite of the intelligent students, whose next pertinent question would be : How do you account for the decreasing trend in temperature from hot end to cold end of the material. The teacher immediately comes up with another simulation experiment.

It consists of a linear arrangements of wooden spheres and springs stretched between two points A and B (say two points directly opposite each other on facing walls of a classroom). In this simulation model, the spheres represent "atoms" whilst the springs symbolise the "inter atomic forces"—a new concept introduced through the learning process. The teacher now disturbs the atom (near the end A) by stretching it slightly, along the line AB. The resultant vibration of the atom (near end A) will be transferred to the end B through the atoms in sequence. However, the students will clearly notice that the amplitudes will go on decreasing as one proceeds towards B. The students are immediately able to conclude that the amplitude of vibration is directly dependant on the temperature, i.e. temperature should fall as one goes from the hot end to the cold end.

Demonstration II

Query (b) is answered with this. For this the instructor needs readily available materials, viz. glass marbles (2 dozens) and a glass tube. The glass tube should have an internal diameter slightly greater than the diameter of the glass marbles, whilst its length may be about 10 (ten) times the diameter. The demonstration part can be carried out successfully on the projection table of the overhead projector, as described below.

The glass tube is first placed on the overhead projector. The marbles are then introduced (one by one) into the tube from one end. The glass tube continues to accommodate more marbles until 10 (ten) marbles are introduced. Here comes the "vital" point. The introduction of the eleventh marble results in the marble (at the other end) being pushed out. So, if now one continues to introduce more marbles at a steady rate, the same number of marbles are pushed out from the other. But, all the time, the tube will hold 10 marbles. The author has found this demonstration to be an excellent illustration of steady state conditions. Now by comparing the "tube" to a rod and the "marbles" to heat supply, the students get a clear picture of heat saturation and subsequent steady state conditions.

The scene now shifts to the practical class where the students are being introduced to be measurement of thermal conductivities of good and bad conductors. The students are taken back to the relation :

$$Q = \frac{KA\,(\theta_1 - \theta_2)}{d}$$

Here θ_1 and θ_2 are temperatures lying between room temperature and 100°C. Further, it is described to keep $(\theta_1 - \theta_2)$ constant or nearly so. Under these conditions, what should be the experimental set up ?

Two possibilities are :

(a) *If K is high* : To have Q within measurable limits "A" should be small and/or 'd' large. This means that for such K measurements, the rod should be long and have smaller area of cross section. This leads to *SEARLE'S METHOD.*

(b) *If K is low* : To have Q of measurable magnitude 'A' should be large and/or 'd' small, i.e. the material should be in the form of a disc—*LEE'S DISC METHOD.* ☐

Images by Two Plane Mirrors Inclined at an Angle

S. A. GANI

"HOW MANY IMAGES OF AN OBJECT ARE formed when it is placed in between two plane mirrors, inclined at an angle?" is the question which puts me in a dilemma when I teach physics to my students. The formula given in almost all the textbooks for the number of images is not correct, therefore, it is not proper to teach according to this formula. I cannot give my formula also to the students because it is not recognised by other teachers. Thus the students who answer according to my formula may lose marks in the examination. The purpose of this article is to prove that the prevailing formula for number of images, i.e. $n=\frac{360}{X}-1$ where X is the angle between the, mirrors, is incorrect and we have to establish a correct and general formula.

According to the prevailing formula the number of images depends only on the angle between the mirrors and is not dependant on the position of the object. But actual geometrical drawings reveal that this is not true. For example, if the angle between two plane mirrors is 80° and the object is placed in two different positions in such a way that the lines joining the object and the meeting point of the mirrors make angles respectively equal to 16° and 35° with one of the mirrors. Then it can be geometrically verified that in the first case the number of images will be 5 and in the second case it will be 4. Hundreds of such examples can be given which prove that the above formula is not correct.

To establish a correct and general formula let us assume that the angle between the two mirrors OA and OB be X° and the line joining the meeting point 'O' of the mirrors and the object 'P' make angles q and r respectively with OA and OB (Fig. 1).

Then if I_1, I_2, I_3.................(q sequence) is the sequence of images of which the first image I_1, is formed by the mirror OA and I_1', I_2', I_3',...........................(r sequence) is the sequence of images of which the first image I_1', is formed by the mirror OB. Then we have.

$$q+r=x^\circ$$

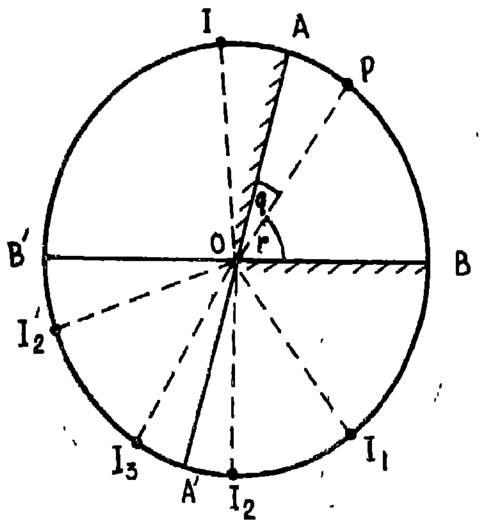


Fig. 1

$\angle AOI_1 = \angle AOP = q$
(F or image of P by OA
$\angle BOI_2 = \angle BOI_1 = \angle BOA + \angle AOI_1 = X+q$
(For image of I_1 by OB)
$\angle AOI_3 = \angle AOI_2 = \angle BOA + \angle BOI_2 = 2X+q$
(For image of I_2 by OA)

Proceeding in this way it can be proved that $\angle AOI_n$ or $\angle BOI_n$ (whichever the case is) $=(n-1)X+q$ where I_n, the image of the 'q' sequence, is the ${}_n$th image. The last image of the sequence is formed on the non-reflecting sides of both the mirrors i.e. in the angle A' OB'.

The angle AOI_n or BOI_n
// $\angle AOB'$ or BOA'
or $(n-1)\ X+q$
// $\angle 180-X$

Hence the number of images of 'q' sequence

$n=\frac{180-q}{x}$ according as $\frac{180-q}{X}$ is a WHOLE Number or a fraction.

Similarly, it can be proved that the number of images of 'r' sequence 'n' is equal to or just greater than $\frac{180-r}{X}$ according as $\frac{180-r}{X}$ is a whole number of fraction.

The total number of images $= n+n'$

If 'Y' is the remainder on deviding 180 by x and angles AOA' and BOB' are drawn in such a way that AOA'=BOB'=Y and the space included in these angles is shaded as shown in the figures, then it is interesting to note that the number of images will be just greater or lesser than $\frac{360}{X}$ according as the object is placed in the densely or rarely shaded region. The number of images will be $\frac{360}{X}$ if the entire space between the mirrors is equally shaded (Fig. 2).

The number of images will be just lesser than $\frac{360}{X}$ if the object is placed on the lines OA' or OB'.

The above facts can be verified by the formula already established. ☐

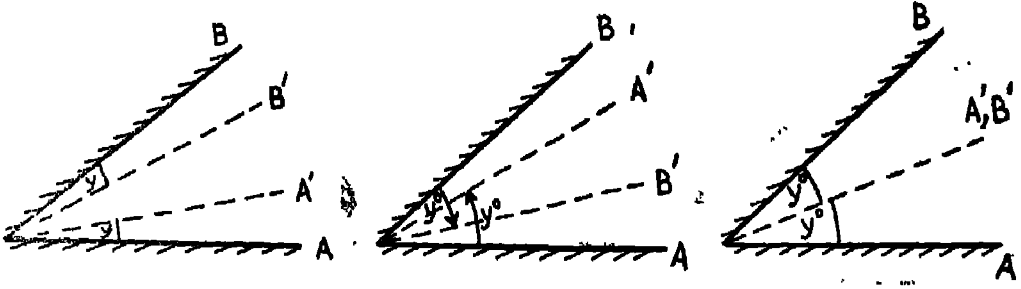


Fig. 2

Creativity : Its Identification and Development*

M. K. RAINA

Reader, Examination Research Unit, NCERT, New Delhi.

RECENTLY PAUL TORRANCE,[1] A DISTINGUISHED creativity researcher, presented research data to prove Plato's famous statement that "what is honoured in a country will be cultivated there". Creative talent needs definitely to be honoured in our country since "at its highest level it has probably been as important as any human quality in changing history and in reshaping the world"[2]. In fact, historical records provide evidence that cultures have collapsed because of the failure to utilize "intelligent, imaginative methods for solving their problems". Therefore, Arnold Toynbee's pertinent observation seems to be correct, that :

> To give a fair chance to potential creativity is a matter of life and death for any society. This is all important, because the outstanding creative ability of a fairly small percentage of the population is mankind's ultimate asset and the only one with which man has been endowed....If society fails to make the most of his human asset or if, worse still, it perversely sets itself to stifle it....Man is throwing away his birth right of being the lord of creation and is condemning himself to be instead, the least effective species on the face of this planet.

It is all the more important for the development of a fully functioning, mentally healthy, well educated and vocationally successful individual. Carl Rogers is afraid that if creativity is not encouraged the lights may go out, there may be individual maladjustment and group tensions as well as international annihilation.

CREATIVITY

In an address in 1962, J.P. Guilford observed that creativity, like love, is a many-splendoured thing, small wonder that few have ventured to define it. A great deal of mist surrounds the word. Since a person can behave creatively in many different ways, it is not strange that we have many definitions of creativity. In one of his letters to the present writer, Paul Torrance wrote that the very fact that a person can be creative in an infinite number of ways may be one of the reasons why we have such a problem of definition. It also suggests that we need to tolerate a variety of definitions and to find a definition that captures more effectively this infiniteness. George K. Bennett[3] who researched the meaning of creativity records that creativity is multifaceted and does not mean the same thing to all people. Moreover, through a diversity of definitions, an amazing consistency can be found. There are certain qualities which can be ascribed to creativity : fluency, flexibility, divergent thinking, originality, inventiveness and the use of preconscious process. To be creative is to have the quality of power of producing "effective surprise" of causing "to come into being, as something unique that would not naturally evolve or that is not made by ordinary processes." Creativity involves "a response that is novel or at least statistically infrequent,....(and) to some extent....adaptive to reality". It concerns "something which is new, rather unexpected, and non-trivial". To Stein creativity is the process which results in a "novel work that is accepted as tenable, useful or satisfying by a group at some point in time". To Frank Barron creativity is the ability to bring something new into existence. Bartelett[4] employs the term of "adventurous thinking" which he characterizes as "getting away from the main track, breaking out of the mould, being open to experience and permitting one think to lead to another". All the contemporary definitions stress novelty, effective surprise and originality. This novelty, according to Bruner[5], grows out of the combinatorial activity—a re-arrangement of perspective.

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*Paper presented to the Unicef Seminar on Science Teaching, RCE, Ajmer, on 10 June 1972

Paul Torrance discusses a process definition in which he lists four ways in which people behave creatively. The first behaviour is the process of sensing difficulties, being aware of problems, or of missing elements in information. This is an evaluative thinking process. The second behaviour is that of formulating hypotheses, making guesses, asking questions, investigating and manipulating information. This is the divergent thinking process which consists of the abilities of being fluent, flexible, original and elaborative. The third is another evaluative process which calls for testing and revising those hypotheses, guesses, or questions which occurred as the second step of the process. Here again, the mental abilities of setting criteria, judging, modifying, re-testing, and remaining flexible come into play. The last behaviour is that of communicating the results to others. This is based upon the study of creative individuals who possess the trait of wanting to tell others about their discovery, invention or innovation. Torrance likes this definition because it is equally useful in all areas of the curriculum, in mathematics, the sciences, languages, the arts, social studies, music, physical education, psychology and human relations. Such a definition places creativity in the realm of daily living and does not reserve it for ethereal and rarely achieved heights of creation.

According to Donald MacKinnon[6], true creativeness fulfills at least three conditions. It involves a response that is novel or at least statistically infrequent. But novelty or originality of thought and action, while a necessary aspect of creativity, is not sufficient. If a response is to lay claim to being a part of the creative process, it must be adaptive to, or of reality. It must serve to solve a problem, fit a situation, or accomplish some recognizable goal. And thirdly, true creativeness involves a sustaining of the original insight, an evaluation and elaboration of it, a developing of it to the full. Creativity, from this point of view, is a process extended in time and characterized by originality, adaptiveness and realization.

Jerone B. Wiesner relates creativity to science as follows :

> The term "creativity" is principally used to mean activity resulting in contributions that have novelty and value in the intellectual sphere of human experience, including the sciences, as well as literature, music, and the visual arts In all such contexts, "creativity" universally implies a departure from, and advance beyond, what is conventionally attainable. However, there is an important characteristic of creative contributions in science that is not significantly present in creative contributions in many other fields, namely, quantitatively definable logical relationships to pre-existing scientific knowledge. Thus, although the emotional and intuitive appeal of a new idea or concept, or its aesthetic richness, may make it "creative" in philosophic or artistic sense, normally it must also meet the criterion of being logically relatable, in quantiative terms, to the body of science in order to be considered scientifically "productive". An idea must clearly follow from what is already known if it is to result in an enrichment of available scientific knowledge or of associated technologies

CREATIVITY, INTELLIGENCE AND ACHIEVEMENT

Perhaps the most frequent concern of researchers has been with the relationship between measure of intelligence and measure of creative thinking ability. The administration of intelligence tests has not proved satisfactory in measuring creativeness. "All available research results support the conclusion that the correlation between measures of creativity and intelligence is low (.20—.40) in general unselected population and practically zero in the selected populations[7]. While there appears to be a positive, but low, correlation between intelligence test scores and creativity, a high intelligence quotient does not guarantee high creativeness, nor does a high creativity quotient (if there is anything like creativity quotient) indicate high intelligence. Thrustone in discussing the correlation between intelligence and creativity commented:

> It is common observation in the Universities that those students who have high intelligence, judged by available criteria, are not necessarily the ones who produce the most original ideas. All of us probably know a few men who are both creative and highly intelligent but this combination is not the rule. One does not expect to find creative talent in a stupid person but there may even be some doubt about this statement because talent in one field can be associated with general mental endowment that is mediocre. There is undoubtedly a positive correlation between creative talent and intelligence, so that geniuses are usually in the upper half of the general intelligence distribution.

Recently, Torrance[8] showed that from a total of 178 coefficients of correlation between measures of intelligence and a total or composite measure of creative thinking ability, the median is .20. The median of 88 coefficients between intelligence and verbal creativity is .21 and the median of 114 coefficients of correlation between intelligence and figural and nonverbal creativity is .96. Although in the studies represented by the distribution given in Table 1, there are certain coefficients of correlation that are both higher and lower than any obtained by Torrance, the central tendencies are about the same.

TABLE 1

Distributions of Product-Moment Coefficients of Correlation between Scores on Intelligence Tests and Scores on Creative Thinking Tests

Coefficient of Correlation	*Total* *Freq.*	*Cum Freq.*	*Verbale* *Freq.*	*Cum Freq.*	*Figural* *Freq.*	*Cum Freq.*
.60 or above	3	3	1	1	0	0
.50 to .59	10	13	2	3	0	0
.40 to .49	13	26	4	8	4	4
.30 to .39	28	54	9	17	3	7
.20 to .29	37	90	30	47	14	21
.10 to .19	33	123	19	66	25	46
.00 to .09	27	150	5	71	29	75
−.01 to −.10	17	167	9	80	26	101
−.11 to −.20	7	174	5	85	8	109
−.21 to −.30	4	178	3	88	4	113
−.31 to −.40	0	178	0	88	1	114
Median	.20		.21		.06	

Source: Torrance, E.P., *Minnesota Studies of Creative Behaviour*, University of Georgia, Georgia, 1967

From the results of his investigations Guilford concluded : "we must look well beyond the boundaries of IQ if we are to fathom the domain of creativity".

For a third of a century, research on intellectual talents has clearly shown that we have talents of many different types, not just one academic (or "general intelligence") type. Guilford's theory of Structure of Intellect suggests 120 possible talents more than 98 of which have now been discovered. From this up-to-date view, typical intelligence tests cover no more than eight talents, about one-tenth of those now known--therefore intelligence tests do *not* cover the other nine-tenths now measurable

Numerous empirical observations speak in favour of the familiar assumption that only those students who have greater intelligence or who excel in the field of what Guilford calls academic intelligence, alone can perform better in the tests of academic aptitude or examination which, by and large, measure the abilities in the area of convergent thinking. Researchers have shown that the creative students can give comparable performance on standard achievement tests; in spite of more than 20-point difference in mean IQs between those scoring in the top 20 per cent on intelligence test (but not in the top 20 per cent on a battery of tests of creative thinking) and those scoring in the top 20 per cent on creativity tests (but not in the top 20 per cent on intelligence). The reason for this phenomenon forwarded by researchers is that imagination, curiosity and similar qualities of the highly creative subjects enable them to compensate for what they lack in memory and other factors measured by a test of intelligence.

Several researches indicate that science instruction in the schools has not rewarded the individual who is creative. Taylor[9] in a study done on creative scientists, found little correlation between academic achievement and high production in industry. MacKinnon[10] in studying outstanding creative individuals found the majority received C's and B's in school rather than A's. Numerous studies indicate that there is not a high correlation between IQ and creative potential. Torrance[11] records :

> Traditional 'tests of intelligence are heavily loaded with tasks requiring cognition, memory and convergent thinking...... In

TABLE 2

*Distributions of Product-Moment Coefficients of Correlation between Creative Thinking Test Scores and Measures of School Achievement Teacher Grades and Teacher Estimate of Creative Potential**

Coefficient of Correlation	Achievement Test		Teacher Grades		Teacher Indent	
	Freq.	Cum Freq.	Freq.	Cum Freq.	Freq.	Cum Freq.
.70 or above	2	2	0	0	0	0
.60 to .69	4	6	1	1	1	1
.50 to .59	9	15	8	9	7	8
.40 to .49	9	24	11	19	5	13
.30 to .39	7	31	22	41	7	20
.20 to .29	8	39	21	82	8	28
.10 to .19	12	51	20	82	8	36
.00 to .09	6	57	18	100	1	37
−.01 to − 10	5	62	8	108	1	38
−.11 to −.19	2	64	0	108	2	40
−.20 to −.29	1	65	2	110	0	40
−.30 to −.39	0	65	4	114	0	40
Median	.28		.21		.20	

*From Torrance, E.P., *Minnesota Studies of Creative Behaviour*, University of Georgia, Georgia, 1967.

> fact, if we were to identify creative children on the basis of intelligence tests, we would eliminate from consideration approximately seventy per cent of the most creative. This percentage seems to hold fairly well, no matter what measures of intelligence we use and no matter what educational level we study, from kindergarten through graduate school.

Torrance made tabulations of the product-moment coefficients of correlation between the measure of creative thinking ability and measure of school achievement based on standardized tests, teacher grades, and teacher estimates of creative potential. The results of these tabulations are presented in Table 2.

It is interesting to note that the median of the 65 coefficients of correlation between creativity measures and standard measures of school achievement is .28. Eight of the reported coefficients of correlations, however, are negative. "It is of interest to note that there is a generally low relationship between creative thinking ability and school achivement, as measured by teacher grades than when measured by standard tests. Relationship between teacher estimates of pupil creativity and measures of creative thinking ability are at approximately of same level. These findings suggest that tests of creative thinking ability might profitably be used to aid teachers in becoming aware of potentialities they might otherwise overlook. Regardless of the tests, limitations, this would seem to be one of their strong assets."

IDENTIFICATION

If deplorbale waste of human talent is to be prevented and if creatively gifted students are not to "choose the paths of delinquency, mental illness, or at best a life of mediocrity and unrealized potentialities it becomes essential that serious attempts are made to identify creative talent." Identification and measurement of creativity will lead not only to a greater understanding of a person but would also provide a more adequate basis for accurately forecasting something about his future[12], and above all, our task as educators is not to recognize creative talent after it has come to expression, but either through our insight or through the use of validated predictors to discover talent when it is still potential and to provide that kind of educational climate and environment which will facilitate its development and expression. Identification of creativity becomes more important in today's high technological society where there is critical demand for inventive scientists and engineers.

Creative person appears to be distinguished, most generally, by two fundamental traits, one intellective, and the other motivational and attitudinal. Creativity, in other words, is not entirely a cognitive process, nor it is entirely a result of complex set of personality traits (Raina and Shukla)[13]. Therefore, a valid assessment procedure would of necessity consider both the components, cognitive as well as motivational or attitudinal. There are several examples of different types of cognitive and motivational or personality measures of creativity which can be used effectively and fruitfully for doing research on creative person or in identifying students with some potential for original or creative thinking. Some of these are described in the following paragraphs.

(a) *Cognitive Measures of Creative Thinking Ability*

Guilford, who is the real dean of creativity, developed various tests of creativity on the basis of his model of intellect. These tests of creativity measure the abilities in the domain of Divergent Production (DP). Most of the areas of creation as Guilford maintains could be accounted by these abilities. These tests measure sensitivity of problems, spontaneous flexibility, word fluency, expressional fluency, ideational fluency, associational fluency, originality, semantic elaboration, re-definition, etc. Guilford[14] has presented much data on the validity and reliability of these tests in his book *The Nature of Human Intelligence* (1969). Getzels and Jackson drew heavily upon the Guilford measures for their study of creativity and intelligence.

Flanagan[15] developed a list which consists of a series of problem situations for which an ingenious solution can be found. It tests the ability to invent or discover a solution which represents an unusually neat, clever or surprising way of solving an existing problem. Mednick and Mednick (1964) too have developed Remote Associates Test based on the associative theory of creative process. It tests the ability to form mutually remote associative elements into new and useful combinations. Wallach and Kogan (1965) designed a battery of tests which measures divergent thinking, developed on the Guilford pattern. They speak of their tests as measured of "idea-producing ability", a "type of thinking capacity," and as a measure of "cognitive vitality or energy".

Torrance and his associates, over a period of about twelve years, have been developing several batteries of test tasks for use in creativity research and for identification of creative students. This test has been used in as many as eighteen cultures after translation. The tests consist of verbal and non-verbal form and are fairly complex and have features that make use of what "we know about the nature of the creative thinking processes, the qualities of the creative products, and creative personalities."

There are other tests also and of late there has been some sort of hyperactivity in designing creative instruments. A detailed description may be found in the author's paper presented to the N.C.S.E. Conference on "Creativity and Undergraduate Science Education" at the University of Aligarh.

(b) *Personality, Motivational and Biographical Measures of Creativity*

A number of creativity researchers have employed personality measures to differentiate the creative individuals from their less creative peers and their results provide some very useful guides for using some personality, attitudinal and biographical measures of studying the creative personality. Probably the most useful and valid measures of creative components are found in the clusters of established inventory scales that are contained in general personality inventories and that have been found to be highly correlated with identified creative behaviour. Some of the important personality measures of creativity are : Allport-Vernon-Lindzey Scale of Values, California Psychological Inventory, Sixteen Personality Factor Questionnaire, the Omnibus Personality Inventory, The Myers-Briggs Type Indicator, Minnesota Multiphasic Personality Inventory, The Preconscious Activity Scale, Torrance's Creative Motivation Scale, Eisenman's Personal Opinion Survey, Measures of Complexity-Simplicity, Creative Science and Arts Scales, Interest Inventories, Alpha Biographical Inventory, and Biographical Inventories.

(c) *Non-Test Ways of Identifying the Creatively Gifted*

Cognitive and personality tests of creativity have their own limitations. Classroom teachers may find it difficult to use these sophisticated and highly technical instruments. "Tests almost always have time limits, and creativity cannot always be hurried or forced. Some highly creative children, we find, have difficulty in writing down their ideas. Others are far more successful in writing down their ideas than they are in communicating them orally. The immediate testing conditions, personality disturbances, unfavourable reactions to time pressures and the like may prevent some highly creative individuals from revealing their creative potential through tests. There are certain behaviours which can help in understanding and identifying the creative child. Torrance has listed the following as examples of specific kinds of behaviours as indicators of creative talent.

1. He can occupy his time without being stimulated.
2. He likes to dress differently.
3. He goes beyond assigned tasks.
4. He is able to amuse himself with simple things in imaginative ways.

5. He may look like he's loafing or day dreaming when he's actually thinking.
6. He questions beyond the single "why" or "how".
7. He experiments with familiar objects to see if they will become something other than what they are intended to be.
8. He is a window watcher during the class, but keeps up with what is going on in the class too.
9. He enjoys telling about his discoveries and inventions.
10. He comes up with ways of doing things that are different from the standard directions.
11. He finds unusual uses of toys other than the intended uses.
12. He is not afraid to try something new
13. He draws designs and pictures on his notebook while the teacher is giving lecture or direction.
14. He draws elaborate pictures.
15. He goes further in his play with games than the directions accompanying them.
16. He doesn't mind consequences if he appears to be different.
17. He uses all of his senses in observation.

The creative child may exhibit six kinds of thinking which are involved in creativity.

1. Sensitivity to problem : seeing defects, needs, deficiencies, seeing the odd, the unusual, seeing what must be done;
2. Flexibility : ability to shift one approach to another, one line of thinking to another;
3. Fluency : ability to produce a large number of ideas;
4. Originality : ability to produce remote, unusual, or new ideas or solutions;
5. Elaboration : ability to work out the details of a plan, idea, or outline, to "embroider" or elaborate;
6. Re-definition : ability to define or perceive a way different from the usual, established or intended way, use, etc.

Calvin Taylor also suggests some behaviours which can help in identifying the creatives in the classroom.

1. Creative persons are more self-sufficient, basing their behaviour upon their own concept of themselves rather than depending upon close supervision and guidance from others.
2. Creative persons are independent in making judgement and are willing to stand alone against the group for the sake of accuracy in their reporting.
3. Creative persons are more self-assertive and dominant, more stable, more self-accepting, more aware of and open to their own impulses.
4. Creative persons are more progressive and radical than conservative, more courageous, adventurous and otherwise more capable of taking greater risks, backed by their own efforts in the hope of greater gains.
5. Creative persons are more complex as persons and may stir up group sanctions against themselves as a result of their new ideas, which may be sensed by others as a threat to their *status quo*.
6. Creative persons are more resourceful.
7. Creative persons are able to tolerate a great deal of ambiguity and can thus go on for a long period of time with unsolved problems and with what others often may feel to be confusion.

8. Creative persons are more likely to give unexpected responses, to pioneer at the frontiers.
9. Creative people are much curious. Many creative scientists report that when they were in school, they learned more about the things which curiosity led them to study on their own than they did from either classroom work or assigned homework.

There are numerous ways of finding and locating a creative student in the classroom. Descriptions by the students of their most trying, most satisfying or most embarrasing experiences, may at time help us in knowing the originality of the student. Much depends on the resourcefulness of the teacher. To identify a creative child, the teacher himself should be creative. But a teacher or educational engineer should make use of all the methods of identification, since no single measure is the best one. Creativity after all is multifaceted and multidimensional.

Nurturance of Creativity

What are our establishments (schools, industries and laboratories) doing to nurture the creative potential which is normally distributed in the population? Do they in any way encourage the creative, inventive and prouctive potential to flourish? Do they provide conducive or responsive environment for stimulation and acceleration of imagination, inventiveness or creative productivity or what a psychologist called "effective surprise"?

Our selection systems, curriculum, methods of teaching instructional technology or textbooks are not in consonance with the development of this human asset. Probably, the urge to enquire, to invent, to experiment is stifled in the millions of school children, resulting in the dearth of creative spirit. The organization of our schools, our curriclum offerings and our textbooks pay homage to the same god of conformity and even the selection system in education emphasizes the convergent abilities at the cost of divergent abilities, independent thinking and independent judgement. Unusual emphasis on intelligence test scores and examinations, which are not the predictors of creative ability, has resulted in a loss of talent. Teachers and teacher-educators by over-emphasizing obedience are mutilating one of the fundamental principles of growth and development. A scheme of things where teacher is god rather than guide will not bring about creativity and originality. In India, the teacher perceptions of an ideal pupil are hardly commendable. There is a great premium on conformity and uniformity rather than on diversity and creativity or the "emergence of originals and of individuality."

The research in creative functioning points to revolutionary changes in educational objectives, curriculum, instruments for assessing mental growth and educational achievement, instructional procedures, counselling and guidance, supervisory and administrative practices and even in school-building planning. In creativity, we have the essence of what is worth saving, in education we have the means[16].

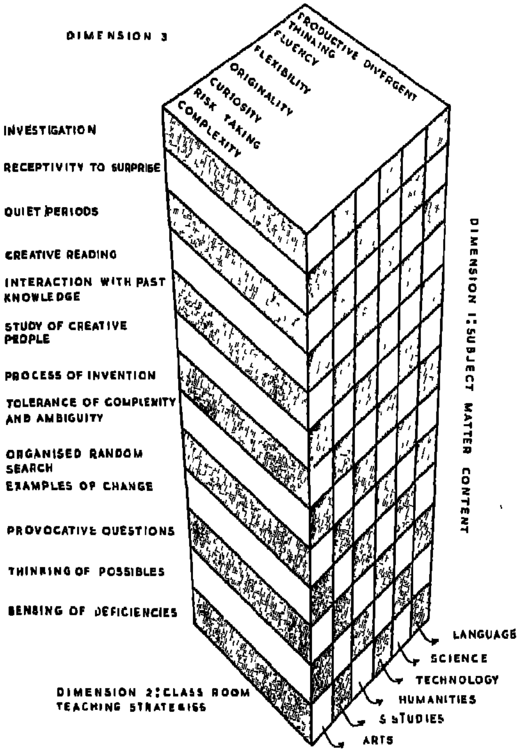
Writing under the title "What Educators can do to Develop Creative Potential," Torrance lists ten suggestions for the development of creativity :

1. seriously considering questions and ideas;
2. asking provocative questions;
3. recognizing and valuing originality;
4. developing ability to elaborate;
5. unevaluated practice and experimentation;
6. developing creative readers;
7. searching for truth through experimental research.

Besides these suggestions, let us consider some more :

1. Find ways of assisting children to be more sensitive to environmental stimuli:
2. Permit and encourage manipulation of objects and ideas.
3. Develop tolerance of new ideas.
4. Beware of forcing a set pattern.
5. Teach the child to value his own creative thinking.
6. Develop a creative classroom atmosphere.
7. Understand the creative process and share this understanding with pupils.
8. Dispel the sense of awe of masterpieces.
9. Encourage and evaluate self-initiated learning.
10. Create "thorns in flesh" to be sensitive to defects, to recognize the disturbing elements.
11. Create necessities for creative thinking.
12. Provide for both active and quiet times for production of ideas.
13. Develop constructive criticism—not just criticism.
14. Encourage acquisition of knowledge in a variety of fields.
15. Become more adventurous and spirited.

Frank Williams[17] has presented a thought-provoking model which provides the teacher with a systematic analysis of classroom practices so that the development of creative thinking is no longer left to chance. It is a three-dimensional model for teaching productive-divergent thinking, in which Dimension 1 presents subject-matter content, Dimension 2 classroom teaching strategies and Dimension 3 productive-divergent thinking processes. The model is presented below.



This model is of much value for producing and teaching creative thinking skills. A detailed description of this model may be found in Raina ("Developmental Models of Creativity," *Creativity Newsletter*, Department of Physics, University of Aligarh, 1972).

Science teaching should strive to help students develop insight into the process of inquiry or discovery while acquiring concepts of science. The students should be led to perceive a problem, to formulate hypothesis, to collect data, to make generalizations, test their predictive quality and, in short, to discover the scientific concept that he is to learn. The intent is that the student in his acts of scientific inquiry, not only acquires a better understanding of the concepts but also an understanding of the nature of science.

Investigative projects may assist in development of creative potential[18]. Many creativity researchers have demonstrated that potential scientists need experience which will enable them to develop an independent spirit and to value the intellectual pursuit. The habit of research should begin in childhood. Independent project, school science clubs, discovery and problem, solving approaches to teaching, which should also involve manipulation of objects and ideas, should help in the development of creativity.

Methodology of science teaching, including instructional media, curriculum, and evaluation system, need considerable modification so that development of creativity becomes a possibility. Classroom questioning, textbooks and teachers' attitudes towards the creative child also need a change. Above all, our job as science teacher should be not to make science an ahuman activity. Otherwise Maslow's contention will prove correct that science will become an uncreative process.

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□

Chemistry of Manganese

L.D. AHUJA

Chemistry Department, IIT, New Delhi

THERE ARE CERTAIN ELEMENTS IN THE PERIODIC table which one can choose for study and make the subject of chemistry very interesting and lively for the youngsters. One such element is manganese. All school students come to learn about it very early in their school career. For example, manganese dioxide is used in the preparation of oxygen gas in the laboratory though the mechanism by which it acts as a catalyst for the decomposition of potassium chlorate is not yet clearly understood.

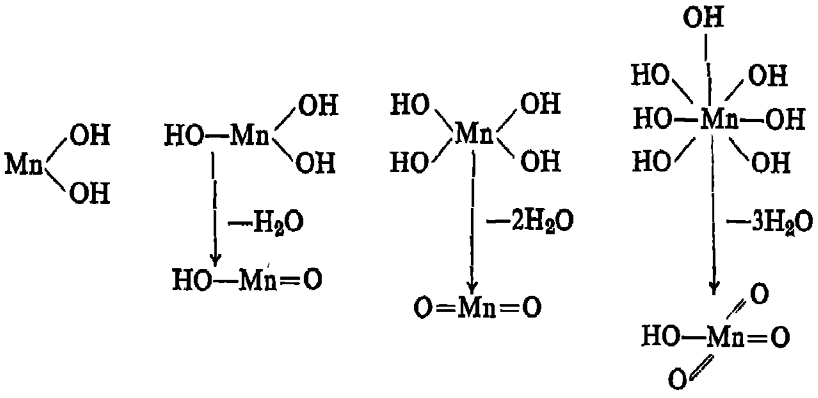
Let us leave these frivolities and come to the topic itself.

Manganese displays all the oxidate states (commonly known as oxidation states) i.e. from +1 to +7, in its compounds, the most important being +2, +3, +4 and +7 exemplified by $MnSO_4$, $MnO(OH)$, MnO_2 and $KMnO_4$. What is perhaps most remarkable is that compounds of manganese representative of all the states except +1 can be prepared starting with metallic manganese and utilizing only KOH, H_2SO_4 and oxygen from the atmosphere.

Furthermore, the oxy compounds of manganese start with the typical basic hydroxide $Mn(OH)_2$, pass through the amphoteric MnO_2 and terminate at permanganic acid $HMnO_4$ — a typical strong acid. These facts are made clear by the following representation.

Oxidate state	+2	+3	+4	+7
Actual formula	$Mn(OH)_2$	$MnO(OH)$	MnO_2	$HMnO_4$

Hydroxy form



Property	Basic	Basic	Amphoteric	Acidic (unstable)
Colour	Pink	Black	Brownish black	Purple

Manganese is an active metal and displaces hydrogen from solutions of acids, e.g.

$$Mn(s) + 2H_3O^+(aq) + 4H_2O(l) \longrightarrow Mn(H_2O)_6^{+2}(aq) + H_2(g)$$

In spite of being strongly paramagnetic, $Mn(H_2O)_6^{+2}$ is stable to oxidation by oxygen. On the other hand, $Mn(H_2O)_2^{+3}$, produced from freshly prepared $Mn(OH)_2$ (flesh colour), which rapidly turns black on exposure to air, is unstable and disproportionate to the oxidate states +2 and +4 of manganese.

Mn(IV) oxide is a strong oxidizing agent in acidic media and may be used to prepare chloric, bromic and iodic acids from their respective halide salts.

Dehydration of $KMnO_4$ by conc. H_2SO_4 yields the anhydride of permanganic acid. The reaction is completed in two steps as follows :

$$KMnO_4(s) + H_2SO_4(l) \longrightarrow HMnO_4 + KHSO_4(s)$$

$$2HMnO_4 + H_2SO_4(l) \longrightarrow Mn_2O_7(l) + H_3O^+(aq) + HSO^-_4(aq)$$

Mn_2O_7 is a dark coloured substance which is violently explosive. Its preparation should never be undertaken without rigorous protection against hazards of explosions.

Note : $KMnO_4$ should neither be treated with strong acids nor should it be allowed to come in contact with oxidizable materials. □

Some Thoughts on Health Education in Schools

S. K. SELUKAR

Assistant Director, Health Services, (Health Education) Maharashtra

THE PROSPERITY OF ANY NATION IS DEPENDENT to a large extent upon the health of its individual citizens. One way of ensuring that the citizens of India are physically and emotionally fit is to provide effective and well planned programme of health and family-life education in schools. Such an educational programme should be aimed at helping children and youth solve the immediate as well as future health and family-life problems. One of the basic goals of health and family-life education in schools is to develop the awareness among the students that community-health and family-welfare are their responsibilities.

Primarily, health and family-life education in schools is the responsibility of the education department. But other agencies also have some responsibility and a close coordination between all the agencies is essential for establishing, developing and implementing effective health and family-life education programme. The need of coordination and collaborative efforts exists at all levels. Steps have already been taken to ensure that effective health and family-life education will take place in Maharashtra. The Government of Maharashtra has formed school health committee at state level, comprising of the health and education authorities. A state-level workshop on health and population education was organized and follow-up measures such as teachers' training, working paper on curriculum, students' health club, development of educational materials for the neo-literates, health knowledge surveys have already been taken up jointly by the Education and Health Department. The W.H.O. Consultant for Health Education is assisting the programme.

In Tamil Nadu, a teacher-educators' training unit has been established under the State Health Education Bureau. This unit is training teacher-educators in health education. This Tamil Nadu pattern was recommended by the Central Council of Health to all the states for establishing such a unit in their states. Accordingly, the Department of Health, Maharashtra, has envisaged such a unit in the State.

In Maharashtra, health education is included in the school curriculum as a compulsory subject. But it is treated as a science subject, and its socio-cultural and practical aspect is not stressed. National programmes on health and role of teachers and students on those programmes are not given. We have come across many teachers of the schools when we ask them who teach health, they are confused. Perhaps it is because of not having distinct entity for health in the curriculum. In such conditions, the impact of health instructions may not be felt. Though we may hold some educational meetings and training programmes on the subject, it may be difficult to percolate to the target audience. So I feel that if health is given distinct entity along with science, say, as Science and Health, the presence of the subject will be felt by the teachers, students, parents and administrators and a sequential syllabus for it can easily be developed with its own objectives. It is true that health is very much related to science but I think that their objectives and methods are somewhat different. In science, we are concerned with knowledge and skill, whereas in health, we are concerned with knowledge, skill, attitude and behavioural change, according to the changing needs of the individual and the community.

How health and family-life education should be developed at this juncture, education authorities know the best. Besides health education in schools, we have to develop health services to the students and improve the environmental conditions in the school. So it seems to me if education department makes a senior educational personnel responsible mainly for school health programmes which can be developed jointly, by the health and education departments, the programme will expand rapidly. ☐

Magnetic Intensity at a Point Due to a Long Bar Magnet

A.B. PATEL, C.M. PATEL, G.K. PATEL

Department of Mathematics and Physics
V.S. Patel College of Arts and Science
Bilimora, District Bulsar
Gujarat

THE FORMULA TO FIND THE INTENSITY OF MAGNETIC FIELD AT A POINT IN XY PLANES[1] IS

$$F=\frac{M}{d^3}\sqrt{3\cos^2\theta+1}$$

In the derivation of this formula, the length of a bar magnet is considered to be very small. Hence, the above formula can not be applicable in the case of a bar magnet having considerable length

Here we have derived by potential method a general formula to find the intensity of magnetic field at any point in XY plane due to a bar magnet having considerable length.

DERIVATION OF THE FORMULA

Let NS be a long magnet of magnetic length 2l, pole strength m, and magnetic moment

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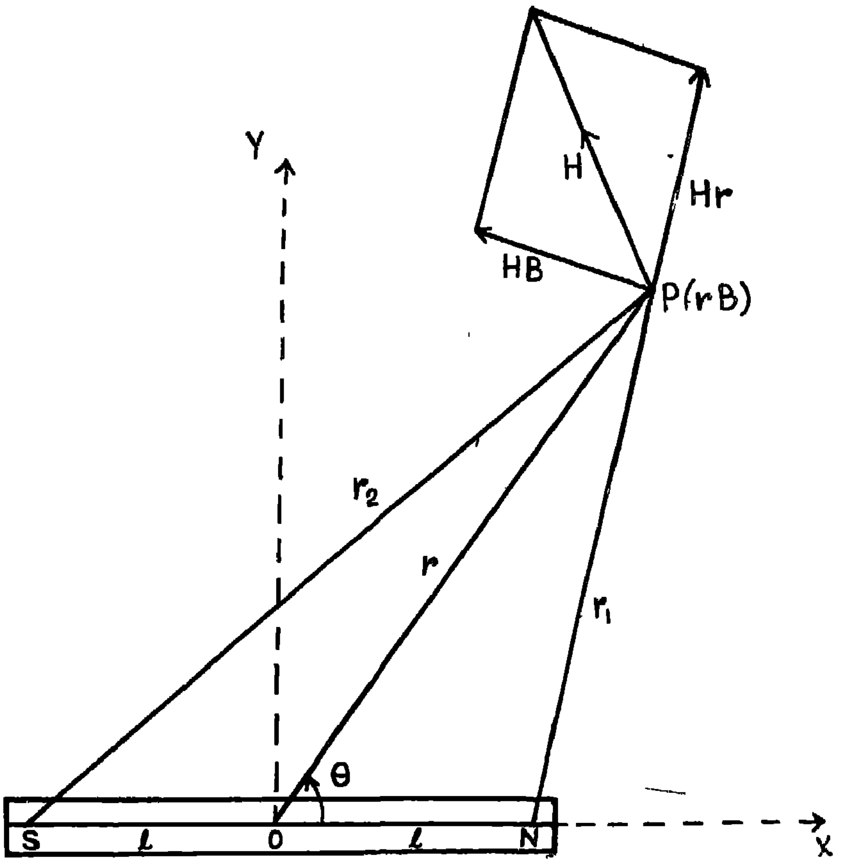
[1] D. N. Vasudeva, *Magnetism and Electricity*, 1964, pp. 17 and 21

M. P is a point in XY plane, at a distance r from the mid point O of a magnet. Let OP makes an angle θ with the axis.



Now the total potential V_p at point P in XY plane due to a magnet NS is

$$V_p = \frac{m}{r_1} - \frac{m}{r_2}$$

$$= m\left\{\frac{1}{\sqrt{r^2+l^2-2rl\cos\theta}} - \frac{1}{\sqrt{r^2+l^2+2rl\cos\theta}}\right\}$$

$$V_p = m\left\{\frac{1}{\sqrt{y}} - \frac{1}{\sqrt{x}}\right\} \longrightarrow (1) \qquad \text{where } x = r^2+l^2+2rl\cos\theta,\quad y = r^2+l^2-2rl\cos\theta$$

Here r and θ is the polar coordinates of P with respect to an origin 0.

Now the intensity of magnetic field at point P along PA (r increasing and θ constant) is

$$
\begin{aligned}
H_r &= -\text{rate of change of potential}\\
&= -\frac{dV_p}{dr} = -\frac{d}{dr}\cdot m\left\{\frac{1}{\sqrt{y}} - \frac{1}{\sqrt{x}}\right\} \quad \text{(From equation 1)}\\
&= -m\left\{-\frac{r-l\cos\theta}{y^{\frac{3}{2}}} + \frac{r+l\cos\theta}{x^{\frac{3}{2}}}\right\}\\
&= m\left\{\frac{(r-l\cos\theta)x^{\frac{3}{2}} - (r+l\cos\theta)y^{\frac{3}{2}}}{(xy)^{\frac{3}{2}}}\right\} \qquad \ldots(2)
\end{aligned}
$$

Now the intensity of magnetic field at point P, along PB (θ increasing and r constant) is

$$
\begin{aligned}
H_\theta &= -\frac{dV_p}{r\,.\,d\theta}\\
&= -\frac{m}{r}\frac{d}{d\theta}\left\{\frac{1}{\sqrt{y}} - \frac{1}{\sqrt{x}}\right\} \quad \text{(From equation 1)}\\
&= \frac{m}{r}\left\{\frac{rl\sin\theta}{x^{\frac{3}{2}}} + \frac{rl\sin\theta}{y^{\frac{3}{2}}}\right\}\\
&= ml\sin\theta\left\{\frac{y^{\frac{3}{2}} + x^{\frac{3}{2}}}{(xy)^{\frac{3}{2}}}\right\} \qquad \ldots(3)
\end{aligned}
$$

Hence the resultant intensity is given by

$$
\begin{aligned}
H &= \sqrt{H_r^2 + H_\theta^2}\\
&= \frac{m}{(xy)^{\frac{3}{2}}}\left[\left\{(r-l\cos\theta)x^{\frac{3}{2}} - (r+l\cos\theta)y^{\frac{3}{2}}\right\}^2 + l^2\sin^2\theta\,(x^{\frac{3}{2}} + y^{\frac{3}{2}})^2\right]^{\frac{1}{2}}\\
&= \frac{m}{(xy)^{\frac{3}{2}}}\left[\left\{r(x^{\frac{3}{2}} - y^{\frac{3}{2}}) - l\cos\theta\,(x^{\frac{3}{2}} + y^{\frac{3}{2}})\right\}^2 + l^2\sin^2\theta\,(x^{\frac{3}{2}} + y^{\frac{3}{2}})^2\right]^{\frac{1}{2}}\\
&= \frac{m}{(xy)^{\frac{3}{2}}}\left[r^2\,(x^{\frac{3}{2}} - y^{\frac{3}{2}})^2 - 2rl\cos\theta\,(x^3 - y^3) + l^2\,(x^{\frac{3}{2}} + y^{\frac{3}{2}})^2\right]^{\frac{1}{2}}\\
&= \frac{m}{(xy)^{\frac{3}{2}}}\Big[r^2x^3 - 2r^2\,(xy)^{\frac{3}{2}} + r^2y^3 - 2rl\cos\theta\,x^3 + 2rl\cos\theta\,y^3\\
&\qquad\qquad + l^2x^3 + 2l^2\,(xy)^{\frac{3}{2}} + l^2y^3\Big]^{\frac{1}{2}}\\
&= \frac{m}{(xy)^{\frac{3}{2}}}\left[x^3(r^2 + l^2 - 2rl\cos\theta) + y^3\,(r^2 + l^2 + 2rl\cos\theta - 2(xy^{\frac{3}{2}}(r^2 - l^2)\right]^{\frac{1}{2}}\\
&= \frac{m}{(xy)^{\frac{3}{2}}}\left[x^3y + y^3x - 2(xy)^{\frac{3}{2}}\,(r^2 - l^2)\right]^{\frac{1}{2}}\\
H &= \frac{m}{(xy)}\left[x^2 + y^2 - 2(xy)^{\frac{1}{2}}\,(r^2 - l^2)\right]^{\frac{1}{2}}
\end{aligned}
$$

Now substituting values of x and y,

$$H=\frac{m}{\{(r^2+l^2)^2-4r^2l^2\cos^2\theta\}}\Big[(r^2+l^2+2rl\cos\theta)^2+(r^2+l^2-2rl\cos\theta)^2$$
$$-2\,(r^2-l^2)\,\{(r^2+l^2)^2-4r^2l^2\cos^2\theta\}^{\frac{1}{2}}\Big]^{\frac{1}{2}}$$

This is a general formula for the intensity of magnetic field at any point due to a bar magnet having considerable length.

Case 1 : *Intensity of magnetic field along X axis.*

Substituting $\theta=0$ and $r=d$, in general formula.

$$H_x=\frac{m}{(d^2-l^2)^2}\Big[(d+l)^4+(d-l)^4-2\,(d^2-l^2)\,(d^2-l^2)\Big]^{\frac{1}{2}}$$
$$=\frac{m}{(d^2-l^2)^2}\Big[2d^4+2l^4+12d^2l^2-2\,(d^4-2^2l^2+l^4\Big]^{\frac{1}{2}}$$
$$=\frac{m}{(d^2-l^2)^2}\Big[16d^2l^2\Big]^{\frac{1}{2}}$$
$$=\frac{2Md}{(d^2-l^2)^2}$$

Case 2 · *Intensity of magnetic field along Y axis.*

Substituting $\theta=90^\circ$ and $r=d$, in general formula.

$$H_y=\frac{m}{(d^2+l^2)^2}\Big[(d^2+l^2)^2+(d^2+l^2)^2-2(d^2-l^2)\,(d^2+l^2)\Big]^{\frac{1}{2}}$$
$$=\frac{m}{(d^2+l^2)^2}\Big[(d^2+l^2\{2(d^2+l^2)-2(d^2-l^2)\}\Big]^{\frac{1}{2}}$$
$$=\frac{m}{(d^2+l^2)^{\frac{3}{2}}}\Big[4l^2\Big]^{\frac{1}{2}}$$
$$=\frac{M}{(d^2+l^2)^{\frac{3}{2}}}$$

Case 3 : *Intensity of magnetic field at mid point of a magnet.*

Substituting $\theta=0$ and $r=0$, in general formula.

$$H_0=\frac{m}{(r^2-l^2)^2}\Big[(r+l)^4+(r-l)^4-2\,(r^2-l^2)\,(r^2-l^2)\Big]^{\frac{1}{2}}$$
$$=\frac{m}{(r^2-l^2)^2}\Big[\{(r+l)^2\}^2+\{(r-l)^2\}^2-2(r+l)^2\,(r-l)^2\Big]^{\frac{1}{2}}$$

$$=\frac{m}{(r^2-l^2)^2}\left[\{(r+l)^2-(r-l)^2\}^2\right]^{\frac{1}{2}}$$

$$=\frac{m}{(r^2-l^2)^2}\left[4rl\right]$$

Substituting $r=0$ we get intensity at mid point of a magnet

$$H_0=\frac{m}{l^4}\times 0=0=\text{zero.}$$

Case 4 : *Intensity of magnetic field at the pole (N or S) of a magnet.*

Substituting $\theta=0$ and $r=l$, in general formula

$$H_n \text{ or } H_s=\frac{m}{(4l^4-4l^4)}\left[(2l^2+2l^2)^2+(2l^2-2l^2)^2-2(l^2-l^2)\{4l^4-4l^4\}^{\frac{1}{2}}\right]^{\frac{1}{2}}$$

$$=\frac{m}{o}\left[16l^4+o-o\right]^{\frac{1}{2}}$$

$$=\rightarrow\infty$$

$$H_n=\text{Maximum.}$$

Case 5 : *Intensity due to a small bar magnet.* when $d>>l$.

To find the intensity due to a small bar magnet we have to neglect the terms l^2, l^3, l^4, etc.

Now from general formula,

$$H=\frac{m}{r^4}\Big[r^4+2r^2l^2+l^4+4r^3l\cos\theta+4rl^3\cos\theta$$

$$+4r^2l^2\cos^2\theta+r^4+2r^2l^2+l^4-4r^3l\cos\theta-4rl^3\cos\theta$$

$$+4r^2l^2\cos\theta-2(r^2-l^2)r^2\left\{1+\frac{1}{2}\,\frac{2r^2l^2+l^4-4r^2l^2\cos^2\theta}{r^4}\right\}\Big]^{\frac{1}{2}}$$

$$=\frac{m}{r^4}\left[2r^4+4r^2l^2+8r^2l^2\cos^2\theta-2r^4+2r^2l^2-2r^2l^2+4r^2l^2\cos^2\theta\right]^{\frac{1}{2}}$$

$$=\frac{m}{r^4}\left[4r^2l^2+12r^2l^2\cos^2\theta\right]^{\frac{1}{2}}$$

$$=\frac{2rlm}{r^4}\left[1+3\cos^2\theta\right]^{\frac{1}{2}}$$

$$H=\frac{M}{r^3}\sqrt{3\cos^2\theta+1}$$

DISCUSSION

As shown in Cases 1 and 2, by imposing required conditions on general formula, we get the same formulas which are used to find the intensity of magnetic field at a point along X and Y axis due to a bar magnet respectively. This shows the correctness of the general formula obtained above.

Also according to Cases 3 and 4 the intensity of magnetic field at its pole is maximum and at its middle point is zero which agrees very well with the theoretical concepts of a magnet.

As shown in Case 5, when magnetic length of a magnet is very small, we get the usual formula, given in abstract. This also shows the correctness of the generalformula. ☐

New Light on the Spread of Leprosy

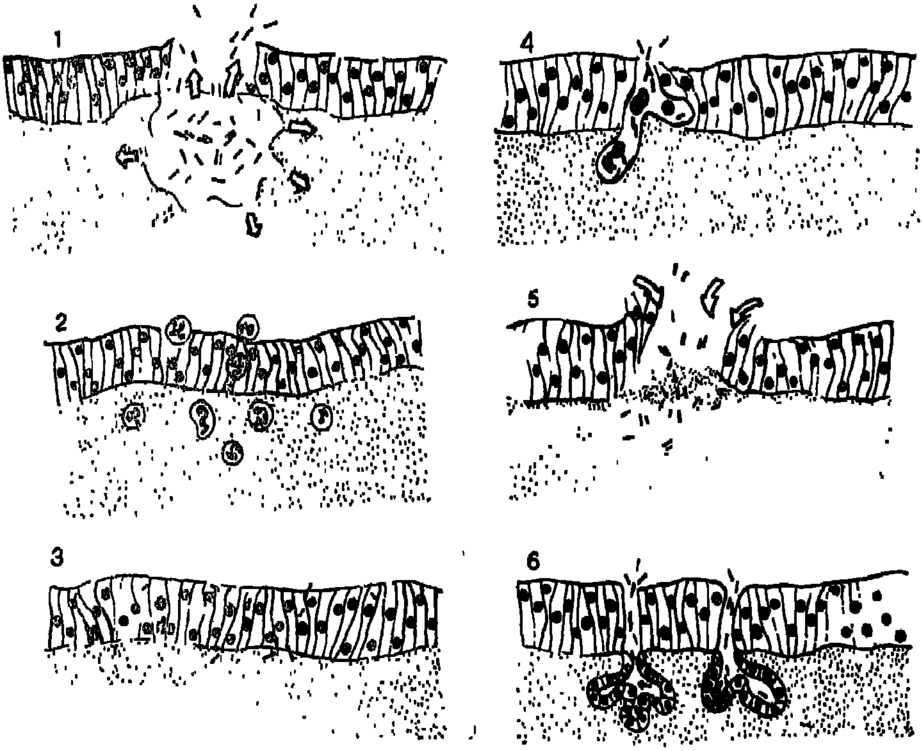
R. J. W. REES

*Laboratory for Leprosy and Mycobacterial Research
National Institute of Medical Research, London*

Research in the last few years indicates that, contrary to popular belief, leprosy is most readily transmitted through the nose, where it forms a seat of infection long before other symptoms have become noticeable. The correct explanation was postulated by 19th century doctors in clearly documented observations, which apparently no one followed up.

LEPROSY IS ONE OF THE MAJOR DISEASES IN THE world today, affecting well over 10 million patients, mainly in the developing countries. It is an infectious disease caused by a bacterium, *Mycobacterium leprae*, related to the tubercle bacillus. Leprosy, like tuberculosis and the other major infectious diseases of man, was recognized as having a bacteriological etiology in the latter part of the last century. But advances in our basic knowledge of infectious diseases which have led to successful methods for their control and treatment have, unfortunately, not helped with leprosy.

The reason it has lagged behind is that, unlike the other causative bacteria, *M. leprae* failed to grow in the test tube (*in vitro*). But while all attempts to cultivate *M. leprae* in vitro have failed, in 1960 Dr. Shepard showed that *M. leprae* recovered from tissues of patients with leprosy multiplied when inoculated into the foot pads of mice. This mouse foot-pad



technique provided for the first time a laboratory method for studying the bacteriology of *M. leprae* and in the last 14 years it has been extensively exploited as a substitute for in vitro cultivation of the other major infectious agents of man. In this relatively short period, the mouse foot-pad technique has enabled our knowledge of leprosy to catch up with that of the other infectious diseases.

In many of these studies the mouse foot-pad infection has been used simply as a substitute for *in vitro* cultivation, but it does have the added advantage providing a laboratory model for elucidating the disease process. It is on the basis of these combined features of the infection in mice that the Medical Research Council, at the National Institute for Medical Research, has attempted to elucidate the mode of transmission in leprosy.

PREVIOUS CLINICAL CONCEPTS

There are broadly speaking two forms of leprosy, the tuberculoid and the lepromatous, and while in both there are skin manifestations and nerve damage resulting from invasion of the tissues by *M. leprae,* there are very many more bacteria in lepromatous than in tuberculoid leprosy. The most heavily infected sites in patients with lepromatous leprosy are the skin, nose and upper respiratory tract so it is from these sites that excretion of bacilli is to be expected. Indeed, in the late 19th century Sticker and Schaffer demonstrated large numbers of bacilli in nasal discharges from leprosy patients and postulated that leprosy was transmitted by bacilli from the nose.

In spite of these early and clearly documented observations, they seem to have been forgotten, since 'prolonged and intimate skin-to-skin contact' has for many years now been favoured as the most likely route of transmission. This probably derived largely from the obvious cutaneous clinical signs of the disease, despite the paucity of bacilli found on the skin surface.

However, from the clinical side interest in the nose and nasal secretions as sources of infection was reawakened in 1970 by Dr. J.C. Pedley working then in Nepal. He convincingly demonstrated many bacilli in stained smears of nasal discharges from patients with lepromatious leprosy, but insignificant numbers of bacilli on the skin surface.

LEPROSY IN THE MOUSE

At the time of Pedley's observations in man, our systematic studies at the National Institute for Medical Research on the evolution of infections with *M. leprae* in the mouse had pinpointed the nose as being a site of particular interest. Thus, the nose appeared to be a favoured site for the localisation and multiplication of *M. leprae* when the infection spread from a locally inoculated foot-pad. The nose was more frequently and more heavily infected than any other tissue site and bacilli were discharged in secretions from the nose, but not discharged from skin sites.

On the basis of these observations in the mouse and Pedley's observations in man a multi-disciplinary project was undertaken to reappraise the clinical, bacteriological and pathological aspects of the nose in leprosy patients, applying techniques which would be likely to determine the importance of nasal infection in the transmission of leprosy.

Average annual age and sex-specific attack rates for tuberculosis leprosy in family contacts, South India

	MALE		*FEMALE*	
Age	*Tuberculosis*	*Leprosy*	*Tuberculosis*	*Leprosy*
0-4	4.0	4.4	3.8	5.6
5-14	1.8	7.3	1.6	2.1

** Survial of M. leprae in dried nasal secretions after discharge*

Number of nasal secretions tested	*Time after discharge (days)*	*Survival of M. laprae* (%)*
3	0	100
3	1.0	100
2	1.75	10
2	3.0	0
1	7.0	1 **
1	10.0	0

Allowed to dry in the dark at a mean temperature of 20.6°C and mean humidity of 43.7%

* Assessed as infectivity in the foot-pads of mice

** Growth of *M. leprae* obtained in only 2 of 12 foot-pads

Thus the bacteriological studies were of prime importance and for these the mouse foot-pad infection was fully exploited.

CLINICAL AND EXPERIMENTAL REAPPRAISAL

The essential clinical link for this study was based on Dr. T.F. Davey at Victoria Hospital, Dichpalli, India, who in 1972 had just completed an extensive study on the clinical and bacteriological aspects of nasal discharges of 936 leprosy patients, which he had undertaken because of Pedley's observations. Davey's data fully confirmed Pedley's findings. In particular, his detailed and meticulous records showed that bacilli could be present in large numbers in nasal secretions when, because of the gross appearance of the patients, skin lesions were not obvious and could easily be missed by routine examination. And, on questioning, patients were found to be aware of unpleasant nasal symptoms, described generally 'sticky noses', and of the frequent presence of blood in their nasal discharges.

In collaboration with Davey, single or 24-hour collections of nasal discharges were taken from a representative sample of patients with active and early forms of lepromatous leprosy. Detailed quantitative studies and biological identification of bacilli from these samples were undertaken in London using the mouse foot-pad technique. These showed that such patients were discharging on average 10^7 viable bacilli daily and that the organisms had the characteristics of *M. leprae*.

Advantage was also taken of the opportunity to study the survival of *M. leprae* in these natural nasal secretions when allowed to dry in the exterior environment, for example, on stone surfaces or in handkerchiefs. Survival was assessed by inoculation of these dried specimens into mice. The studies showed that *M. leprae* was fully infectious for mice one day after drying, some 10 per cent were still infectious at approximately two days, while in one such specimen approximately one per cent of bacilli was still infectious at seven days.

These studies established for the first time that *M. leprae* is relatively robust and can survive drying, in the dark, for several days in natural nasal secretions.

NEAR THE SURFACE

In addition to the bacteriological studies, detailed clinical and histological observations of the noise were undertaken in collaboration with Davey and Mr. R.P.E. Barton, an ear, nose and throat specialist, on 36 patients with early lepromatous leprosy. From each of these patients 3-5 small pieces of tissue were taken from nose by Mr. Barton. Representative samples of these tissues were submitted for bacteriological examination, and for histological examination by Professor A.G.M. Weddell and Dr. A.C. McDougall at the Department of Human Anatomy, Oxford.

Quantitative bacteriological studies on these tissues as compared with pieces of skin from the same patient showed that the nasal tissues were more heavily infected and contained a higher proportion of viable *M. leprae* than the skin. The histological studies confirmed this, but even more important was the finding that the leprosy infection in the nose was only just beneath the surface mucosa, which was often invaded or eroded. Bacilli were frequently present in the cells of mucus glands and ducts. Small blood vessels reached up to the denuded surface of the nasal mucosa and these vessels were dilated and frequently undergoing degeneration.

These histological observations clearly demonstrated the ease with which *M. leprae* could reach the surface of the nasal mucosa and be discharged into the exterior.

Such a multitude of escape mechanism of bacilli from the nose fully explained the large numbers of *M. leprae* present in nasal secretions The histological situations in the nose, therefore, was in complete contrast with that in the skin, where the leprosy infection was deeply situated and not in juxtaposition with the skin surface. In fact the skin infection was clearly separated from the surface by a bacillary-free zone—referred to as the 'clear zone'.

A particular feature of the histology of the nasal tissues was the invasion of bacilli into the lining cells of the blood vessels and the presence of very large numbers of bacilli free within the lumina of the vessels. Because it was impossible to obtain samples of blood from these vessels, an attempt was made to estimate the number of *M. leprae* present by measuring the area of these tissue-sections and their thickness. On the basis of these assessments it was shown that approximately 10^9 bacilli/ml blood were present.

IMPLICATIONS

These specially designed multi-disciplinary studies not only add considerably to our knowledge of nasal infections in patients with leprosy but provide very strong evidence in support of the nose as the primary site by which leprosy bacilli are discharged to the exterior, and therefore the importance of the nose in the transmission of the disease.

Thus, for the first time bacilli discharged from the nose have been established *M. leprae* by their behaviour when inoculated into mic. Moreover, the number of *M. leprae* discharged daily from the nose of lepromatous patients in comparable to the number of tubercle bacilli discharged in the sputum of patients with open and active tuberculosis. Of still greater significance is the evidence that *M. leprae* are relatively robust and can remain viable in dried nasal secretions for several days. Detailed histological studies of nasal tissues clearly show how readily bacilli can reach the surface and be discharged from the nose as compared with infections in the skin.

Together, these findings begin to build up a composite picture for the possible mode of spread of leprosy that has not hitherto been available, at least on the basis of scientific evidence. For not only do they suggest a source of infection, they also offer a possible explanation for the apparent failure of the chemotherapy used for overt disease to help with primary prevention of leprosy in endemic areas. The early lepromatous patient, shedding millions of *M. leprae* from nasal lesions, may infect many people in his family or in his environment before he is diagnosed; and his subsequent treatment may be largely irrelevant in terms of his ability to spread the disease further.

This is a pessimistic picture, but it is important to recall that patients at an early stage have symptoms of nasal blockage and bloodstained nasal discharges. Therefore it may be possible to identify cases earlier by stressing the importance of these symptoms.

Spread involves not only a source of infection but also a portal of entry. Here analogies with tuberculosis may be helpful. Clearly, *M. leprae* could be spread by sneezing, coughing, spitting and unhygienic nose-cleaning methods—so in many respects by way of droplets, as in tuberculosis. In this context, the similarities in bacterial loads from nasal secretions and sputum of patients with lepromatous leprosy and open tuberculosis are of considerable interest.

Clearly, the portal of entry could still be the skin; but, equally, *M. leprae*-laden particles could also be inhaled or swallowed. It is therefore of interest that the attack rates for the two diseases in household contacts are of the same general order, especially in the young. These comparisons prove nothing, but they do suggest—and really for the first time—scientific ways of studying leprosy transmission.

BACK TO THE BLOODSTREAM

An unexpected but very significant finding from the histology of nasal tissues from leprosy patients was the very high concentration of bacilli free within the lumina of nasal blood vessels. As I have said, calculations from these tissues indicated an order of 10^2 bacilli/ml of blood.

This tremendous difference between the concentration of bacilli within vessels of the nose compared with the general circulation is again of particular importance. It could be that the special vasculature of the nose is acting as a 'backwater' in which bacilli from the general circulation gravitate. However, bearing in mind the particularly high concentration of *M. leprae* in nasal tissues, plus the evidence from the mouse that the nasal tissues are a favourable site for the multiplication of leprosy bacilli, it seems more likely that the nose is also a site from which bacilli are readily shed into the bloodstream.

If this is true then nasal infections in leprosy are of the greatest importance, since they represent not only a site from which bacilli reach the exterior and lead to the transmission of leprosy but also a particularly favourable site from which bacilli are fed back into the rest of the body.

So the application of sophisticated biomedical techniques now implicates the nose in elucidating many of the mysteries surrounding the pathogenesis and transmission of leprosy. But those who have diligently applied these techniques must admit that this is what our forefathers hypothesised in the late nineteenth century.

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The Science in Science Fiction

A SCIENCE FICTION IS NOT FICTION ALONE, NOR is it an Irrational Flight of imagination.

What then is science fiction ? Often it is an imaginary projection, or, let us say, thinking in terms of the future, of some scientific facts, theories, speculations, discoveries and inventions. A science fiction writer does not necessarily have to be a scientist But he should closely follow the current scientific developments.

From now on, we will discuss the scientific basis of one science fiction in this column in every issue of this quarterly. In this, we will see how a writer weaves a world of phantasy or 'impossibility' by closely studying the trend of scientific researches. For instance, a writer, who has been following the current researches on spaceships and journeys to distant planets, may project an imaginary view of a journey to the Saturn which, though lying far beyond the range of our spaceships at their present stage of development, may not, or will not, remain unknown to us.

In fact, some classic science fiction writers like Jules Verne or H. G. Wells, had been prophetic in their future vision of scientific development. Jules Verne, long before the technologists could devise a submarine, thought of such an underwater ship 'Nautilus' in his *20,000 Leagues Under the Sea*. His and H. G. Wells' vision of man reaching the moon has become a reality today. They dreamt of a trip to the moon many decades before our first spaceship landed on the moon.

But there are certain things in the continuous flow of scientific research, which are 'theoretical possibilities'. For instance, by changing the structure and components of the nucleus of a uranium atom, it is possible to change it into a gold atom. But this transformation is not practicable. Or, let us take up a scientific speculation which gained currency in the later half of the last century: that by grafting some vital glands of an animal on to the gland system of a man, it is possible to transform a man into a half-beast, or the other way round, by this process, a beast can be transformed into a half-man. This 'scientific' speculation has been the base of H. G. Wells' *The Island of Dr. Moreau*. And on another such speculation Robert Louis Stevenson based his all-time classic *Dr. Jekyll and Mr. Hyde*. Some science fictions are based on such 'theoretical possibilities'.

The art of science fiction reflects man's creative imagination which is the starting point of all scientific discoveries, theories and inventions. It is wrong to think that creative imagination is something 'literary', something 'poetic'. All enquiries, if they are scientific, are creative. They are imaginative attempts to find a new path to the solution of an old problem, or to a set of so-far-unknown laws of nature, or anything for which we are indebted to scientists, philosophers, literary artists, composers of music, painters, sculptors, architects and engineers.

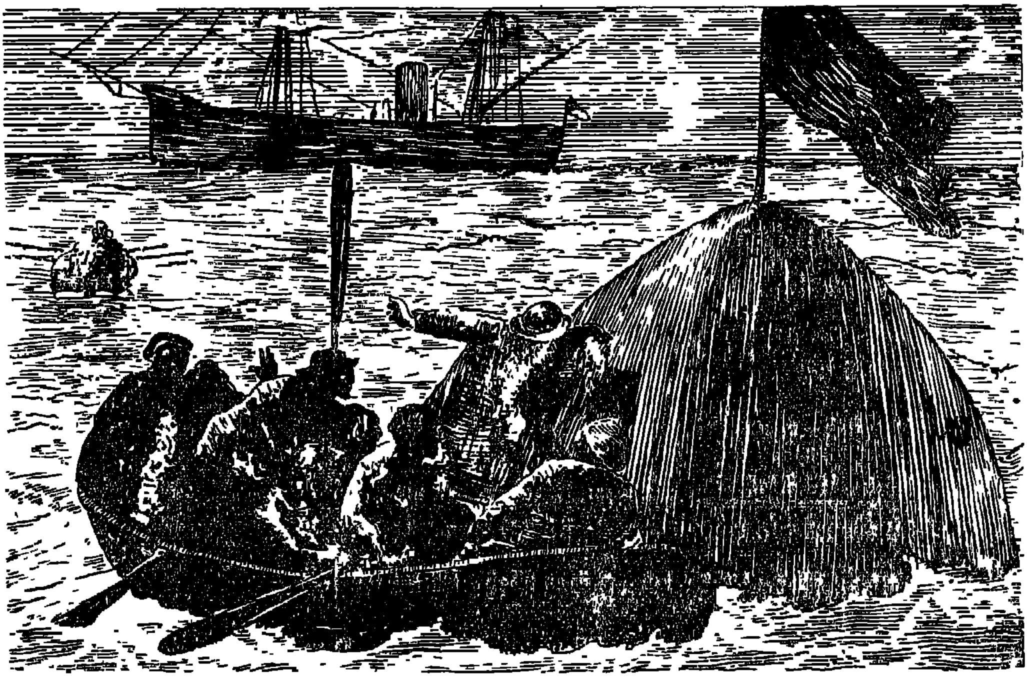
But, you may say : "Granted. But why we, the students of science, should read science fictions ?" A legitimate question, if we believe that scientists deal only with hard facts. But it is a wrong notion. It is precisely to dispel this kind of notion that we have started this column. Any scientific achievement is as much a product of an imaginative mind as it is based on hard facts.

A scientist worth his salt has the power of seeing future possibilities in a set of hard, known facts : *they leap from the known to the unknown.* And this power is nothing but his developed faculties of imagination and reasoning which are based on facts.

The foremost reason for reading science fiction, or any fiction for that matter by a great literary, artist, however, is to taste its literary excellence. If you have not already read the science fiction classics mentioned above, read them and then you will know what you missed. *Literature is not a contradiction of science. In fact, one complements the other in our knowledge and understanding of men and the world around us.* You should not be surprised to learn that almost all the eminent scientists are well versed in literature and poetry.

Secondly, in a work of science fiction you experience the sweeping breadth of creative imagination. A whole new world of possibili-

YESTERDAY'S FICTION IS TODAY'S FACT



Jules Verne wrote a science fiction about man's voyage to the moon, hundred years ago. His spaceship, Columbia, took off from Florida and landed in the Pacific ocean after completing a trip to the moon (see an old illustration above).

In July 1965, Apollo-11 did exactly the same.

ties is thrown open to you. You will start thinking of possibilities in your own area of study and you might be interested in knowing the other areas too.

This, we think, is a sufficient reason for reading things outside your syllabus or course of teaching. Because it achieves two things: it makes you 'think' and it encourages you to venture into other areas of science. It enables you to experience *the relationship between all the sciences, arts and the society.*

THE DAY OF THE TRIFFIDS

The particular work of science fiction we are going to discuss in this issue is *The Day of the Triffids* by John Wyndham (Penguin Books).

The writer creates a strangely fearsome situation. A so-far-unknown species of plant—the author names it Triffid—is multiplying at an alarming rate all over the world. It is carnivorous and at the same time it can draw its sustenance through its roots struck in the soil. But it is a plant that can move, that is, it can draw up its roots from the soil, use them like legs, and go in for the dead, decomposed bodies of men and animals.

Tall, moving on their tripod-like legs, the triffids draw their food through whip-like antennas that suck the decaying dead bodies.

They can "hear" and, following sound or human voices, they "walk" close to the source of sounds and hit out at the living beings around them with their antennas which are full of deadly poison. One stroke is enough to kill a man.

In the triffid, we have a plant that shows many animal features: sense of hearing, power to move around, an active offence mechanism, a kind of 'intelligence'—all suggestive of a highly developed coordination system. The only thing they lack is the sense of sight.

But you may ask : "Can such a 'Plant' suddenly appear on earth ? Has not every species evolved out of its earlier type through millions of years ? Has not the author, by imagining such a plant, denied the process of evolution ? If so, what is then so "scientific" about this particular science fiction ?"

Our answer : the author has not denied the process of evolution. What he has done is that he has based his story on long-exploded Lysenkoism.

Now, what is Lysenkoism ?

LYSENKOISM

Trofim Denisovich Lysenko, the Soviet biologist (1898—), held that a new species can be formed if some members of the species can be exposed to a sudden "shattering" shock that would "shake" their hereditary traits "off". Consequently, the progeny of the individuals might develop new traits which their preceding generations never had. This is Lysenkoism in a very simplified form.

John Wyndham, the writer of the book, has taken off from this theory-base which, though discarded by the scientists, is still very interesting.

One of the "shattering agents", Lysenko argued, could be the grafting of two or more different plants. The individual components of the grafts would influence one another and would eventually emerge into an altogether new plant within a few generations. The author of "triffids" uses this view when one character of the story describes the triffids. "I do not say there is no sunflower there at all. I do not say there is no turnip there. I do not say that there is no nettle or even no orchid there. But I do say that if they were all fathers to it they would not none of them known their child." The author tells us how the seeds of this plant were preserved as a secret biological weapon by one of the superpowers. An agent working for another superpower wanted to steal these seeds. He could manage to secure some and tried to fly out of the country. His plane was shot down and the seeds were strewn in the air. The cloud of these seeds settled silently on the soils of distant lands and thus the triffids had spread throughout the world.

So much for Lysenkoism and the triffids. Along with the new menace, triffids, the author creates a more terrible situation for mankind.

There appeared in the sky spectacular green clusters of shooting meteors. They were visible everywhere in the world. What a spectacular sight! For a few days men, women, children went on looking at the green glow of the shower of meteores all over the globe. Those who could not come out to see the grand spectacle were the sick, or the imprisoned ones or they were very much tied down to some other business.

Now comes the greatest calamity for mankind. Because of the long exposure to the green glow of the meteors, about ninety per cent of the world population becomes blind. The fortunate were only those who could not look at the shooting meteors for some reason or the other.

Let us see how far scientific is the blinding green flashes of the shooting meteors. When they appeared in the sky, it was believed that the earth's orbit passed through that of a comet. But the author himself doubts this explanation. Because the possibility of an overlapping of the orbits of the earth and a passing comet is almost nil. The story of shooting stars with bright green colours is also inexplicable. Why green ? The shower of meteors and the blinding effects of their radiations may be natural phenomena but they cannot be associated with "green flashes". So the author leads us to another explanation: it may be, again, another remote-controlled secret weapon which was originally designed to blind the population of an would-be enemy state. It accidentally got into action, affecting the whole world. The author says : "sustained research in rocketry...succeeded in attaining one of its objectives. It had sent up a missile (or hundreds of such missiles) which stayed up. It was, in fact, possible to fire a rocket far enough up for it to fall into an orbit round the earth...until the pressure on a button should give it the impulse to drop back with devastating effect". One of these devastating effects could very well be various radiations, especially UV—the ultraviolet—rays which can destory the retinal cells of the eye.

The satellites designed to conduct such biological warfare are no more fictions; they are today's reality.

Moral and Social Questions

At this stage we come to a different area of thinking, involving two sets of very disturbing moral and social questions. What kind of society would it be if only ten per cent of the world population remain sighted ? Would the blind be left to fend for themselves ? While knowing that it would be impossible for the sighted to survive the calamity if they take on the burden of the blind, must the fortunate few sacrifice themselves for the blind majority ? Would not that make the whole human species die off ?

Besides, now that most of the man have become blind, how would mankind defend against the triffids who can attack and kill any time, anywhere ?

The second question: Should the scientists use their genius for developing destructive biological weapons that can ruin the whole population of a country by blinding them or making them seriously sick ?

The Day of the Triffids offers you the picture of a terror-stricken world where man becomes the cause of his own destruction.

The readers of the journal may write to us about the science fictions they have read and which they want us to discuss in this column (provided we have those books with us).

Utpal Mallik
Santo Datta

Science News

Benefits of "genetic engineering" outweigh hazards

THE POTENTIAL BENEFITS OF "GENETIC engineering" outweigh the possible hazards of the techniques, and if strict precautions are taken there is no cause for public concern. These are the main conclusions of a working party set up by the advisory board of the U.K. Research Councils, under the chairmanship of Lord Ashby. It says it is important to stimulate enquiry into this field of research, its possible applications and its social consequences.

Genetic engineering is a crude term for subtle work on transferring genetic material (DNA) from the chromosomes of one organism to another. Strands of DNA can be cut by an enzyme in such a way that they will join up again with other strands cut in the same way. As the material controls the processes of cells, it may be possible to transfer characteristics of one organism to another.

The actual incorporation of altered DNA is complicated, though techniques are being refined, and so far the normal chain of protein production that starts in cells from the "blueprint" DNA has not been achieved with the doctored material. Nevertheless, the possibilities are clear and the potential hazards and power of such a process aroused enough anxiety in the scientific community last year for an American group to appeal for certain types of experiment to be stopped until there was more information about dangers to human health. The subsequent public debate was the reason for the setting up of the working party.

For scientists, genes are more than an exciting puzzle. It may prove feasible to insert genes to produce natural substances lacking in individuals, such as insulin to cure diabetes, or to control the runway cells of cancer. Wheat might be made to extract nitrogen direct from the air—a development which would have a colossal effect on world food supplies.

The research work is being done with bacteria : their genetic systems are simple and they reproduce quickly. Most of the hazards the report mentions stem from this. They include the possibility of producing drug-resistant strains and the transferring of unknown characteristics to bacteria that could infect human beings. The organism likely to be most used in research is a species that is a normal one in the human gut, although the strain is not.

The working party concludes that the research should go on, though safeguards should be tightly organized. Many biological laboratories have always used methods of containing pathogens so that they connot cause harm, and the report suggests a number of ideas that might be the basis of a code of practice for the future. They include the appointment of biological safety officers to keep a close watch on loboratory materials and routines and the use of bacteria or fragments of them that would have "built-in" safety—in other words, with genes that would make them unable to survive in the human gut.

How to speed up seed breeding

The time taken to produce new varieties of essential crops, perhaps in order to anticipate the threat of a disease that would decimate the existing varieties, can probably be reduced by adopting tissue culture techniques.

TO PLANT A 100-ACRE (40-HECTARE) FIELD OF commercial barley at the customary rate of some one hundredweight of seed to the acre (125 kilos per hectare) requires something like five tonnes of true-breeding (homozygous) grain, in fact 50-70 million seeds. These, and all the other seeds of the same variety, might well have been derived from the relatively few seeds obtained from programme designed to introduce some desirable characteristic such as resistance to disease, earlier germination or extra-short straw length.

The whole process might have taken 10 or 12 years : first the years of selective inbreeding in order to produce a small number of seeds, all genetically the same, then more years to multiply this number, first to provide enough seeds for testing and then to provide the tons needed by the commercial farmer.

Scientists have recently been looking at tissue culture techniques for propagating plants. Some of these techniques, involving tissues connected with reproduction such as anthers—the pollen repositories—have been successful with some plant species and have led to general optimism the technique can be widely applied for producing homozygous varieties much more quickly.

The reason for this optimism lie in the nature of the pollen grain itself. Like most sex cells, it is haploid—each grain contains only half the normal complement of genetic material, seven single chromosomes instead of the seven pairs common to barley cells. This means that if such a cell could be made to develop into a plant all the cells in the plant would also have single sets of chromosomes and it is unlikely that the plant would be able to reproduce. But treatment with colchicine, the extract of the root of autumn crocus, causes all the chromosomes in all the cells to double up so that the plant can continue to develop normally.

The difference between such a plant and one derived from normal sexual reproduction is that in the colchicine-treated plant both members of each chromosome pair will be absolutely identical. This means that the plant will breed true from then on, a very important feature for the plant breeder.

Inefficient

Scientists at the Welsh Plant Breeding Station at Aberystwyth succeeded in producing a number of barley plants of one particular strain by anther culture, and from these plants obtained seed enough to plant up a small plot. When sown in the winter this yielded enough seed in the summer to cover a field, planted in New Zealand (to get the benefit of two summers in a year), the field of seed yielded enough true breeding grain for a more extensive trial.

From the commercial point of view the snag lay in the inefficiency of the anther culture technique. It was found difficult to do better than one plantlet that would grow from every 100 attempted anther cultures, which meant an impossible wastage of time and money. To be economically viable a success rate at least three times this was needed.

In the technique developed for culturing barley tissue—much the same for any tissue—small pieces of anther with pollen grains attached were cut aseptically, mounted on filter paper and bathed in special nutrient medium. The composition of this medium is a vital factor in the success of the operation, each anther appearing to require its own formulation. For barley anthers the highest success rate was obtained with a medium containing mineral salts, vitamins (5), amino acids (2), auxins or plant hormones (2), sucrose, agar, caustic soda and coconut milk, a most important ingredient of tissue culture media.

The function of the medium is to cause the tissue, in this case the pollen grain to de-differentiate, or lose its specialized structure, and form a callus—a mass of cytologically unstable cells similar to a tumour. In this callus one cell will usually re-differentiate eventually and grow into a haploid plantlet. In the case of the barley anthers. This happened in a few of the calluses. Less than one in a hundred plantlets were produced to be converted into true-breeding diploids by treatment with colchicine.

One Important Success

To date the technique of anther culture can be applied only to a few species of plants and even then with poor efficiencies, as in barley. Only rarely is it successful, as in nicotiana, an ornamental tobacco plant, and more recently in some varieties of potato that flower and produce anther—an important success since it means that potato famine such as occurred in Ireland, last century need never again be allowed to assume such significance because varieties resistant to the kind of diseases that ruined crops in the late 1800s could quickly be produced.

The problem being studied today is why some anthers will behave as required and some will not. In the first place, pollen development may depend on the presence of one gene in the genetic blueprint which is responsible for the production of a hormone substance that either allows or stops development. There may also be other factors in the genetic made-up which control the rate of success. They must all be looked for, and experiments are in hand to examine a number of differences in success rate.

Again, a number of variants of the technique are being examined. In one, a variety of commercial barley hordium vulgarium containing some desirable characteristics is produced and finally crossed with a wild variety hordium bulbosa to produce an apparently normal diploid seed. When this seed is sown, however, examination shortly after germination shows that the hordium bulbosa chromosomes have disappeared—they have either been absorbed or eliminated in some other way—leaving a haploid vulgarium plantlet which an subsequently be made diploid by treatment with colchicine and multiplied as a true-breeding variety.

The success rate in small-scale experiments with this technique is much higher than the minimum required for commercial success, but so far it is only applicable to barley. A similar technique, applicable to many plant species, is to produce plantlets of an apparently suitable variety and to treat them with a substance para-fluoro phenylalanine, which causes one member of each chromosome pair to disappear, leaving behind haploid plantlets. These, when treated with colchicine, revert to the diploid state but with each member of the chromosome pair identical; into a homozygous variety.

Amino-Acid Key ?

A recent discovery made by Colette Nitsch in France could be of great importance. She found that it was difficult, if not impossible, to make pollen grains grow if they were separated from the anther, but that if she treated separated pollen grains with a hot water extract of anther extract of anther wall the pollen grains could be made to grow relatively easily. The active ingredient effecting this change was found to be an amino-acid-serine.

So far the only haploid tissue considered for culture is the pollen grain, which is produced in a form suited to the technique. It is a specialized cell which differentiates further to produce nuclei concerned with three different functions. Two nuclei, both haploid, are responsible for the growth of the pollen tube down the stigma and the fertilisation of the ovule. The third nucleus is responsible for the production of the endosperm which nurtures the developing embryo.

It may be possible to try making some of these haploid tissues develop as well as some on the female side of the process. These are much less prolific than are the male tissues, but they may make up for this by achieving much higher success rate. □

Students' Forum

BROWNIAN MOTION

BROWNIAN MOTION SUGGESTS THAT WHEN LIGHT is focused on a colloidal solution and the suspended particles are viewed under a high power microscope, kept perpendicular to the direction of the light rays, the particles are found in a constant rapid zig-zag motion in all directions known as Brownian motion.

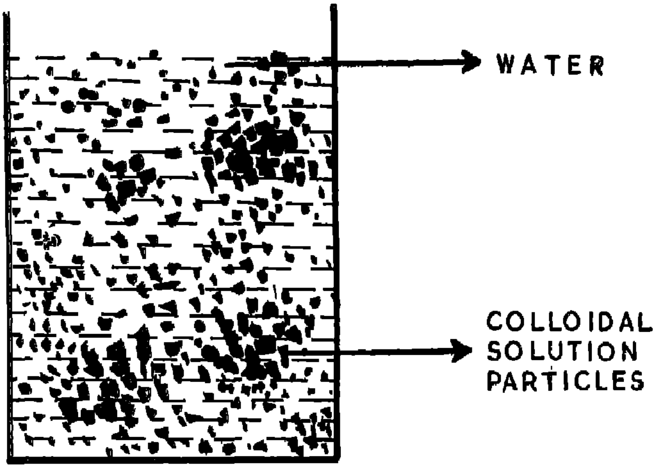


Fig. 1

The reason which is stated for this motion is that the colloidal particles collide with the molecules of the liquid and hence follow a random path.

The above reasoning, however, is not satisfactory. The fact that the colloidal particles are visible under an ultra microscope, itself suggests that they are far greater, both in mass and volume, than the molecules of the liquid in which the particles are dispersed. This reflects the truth that the motion of the particles is not due to the collision of the particles with the liquid molecules. It would be like table tennis balls—dozens of them—striking against a lead ball of the size of a football. The balls will be striking with a force at every point on the surface but the resultant force of all these forces will not be able to move the lead ball in order to cause the random motion.

The forces which can be considered to be acting upon the colloidal particle in the liquid are :

(1) Its weight (mxg) acting vertically downwards.

(2) Buoyant force acting in the upward direction.

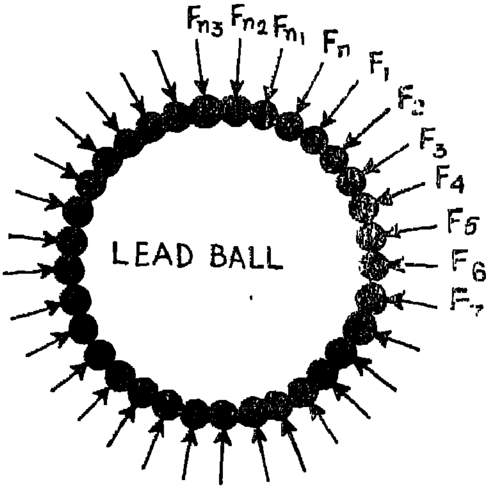


Fig. 2

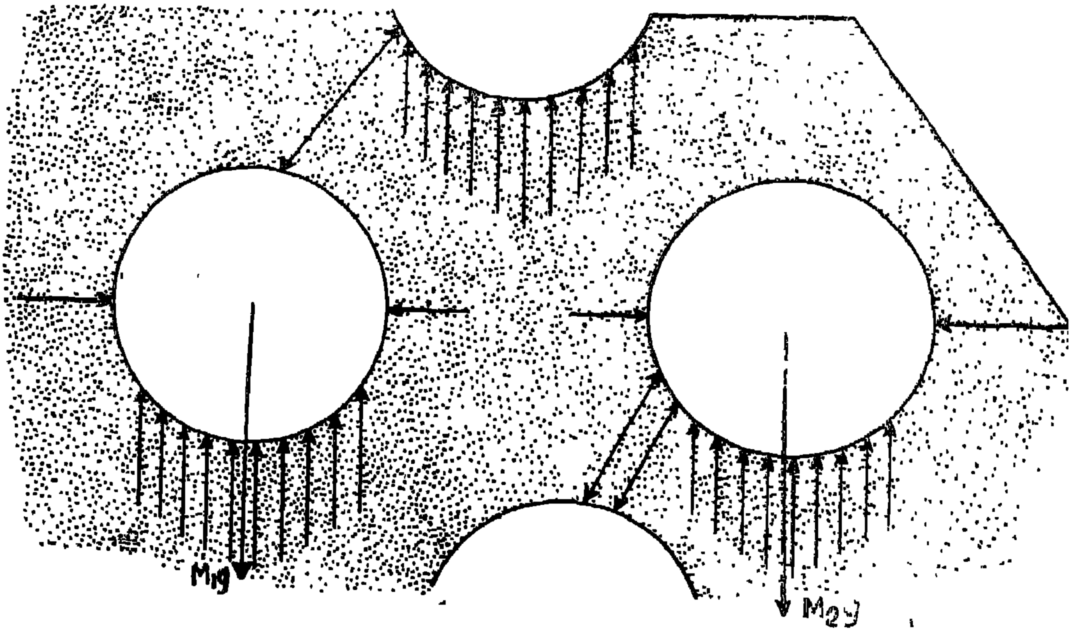


Fig. 3

(3) Force of attraction due to the liquid molecules $F=Km_1\,m_2/r^2_{12}$

(4) Force of attraction due to the other colloidal solution particles in liquid $F=Km_1\,m_2/r^2_{12}$

The weight of the particle and the buoyant force act in opposite directions. The direction of the resultant of the two depends upon their magnitude.

The other two forces, which are due to the liquid molecules and the other colloidal solution particles, are given by the formula $F=K\,\frac{m_1\,m_2}{r^2_{12}}$. The mass of the liquid molecules is extremely small and hence the force of attraction between the molecules and colloidal particles is very less as compared to the force of attraction between two colloidal solution particles. Hence the force due to the attraction between two colloidal solution particles may be the chief force that comes into play.

Let us suppose there are 'x' similar colloidal particles above a certain particle and 'y' below it. Of course, there are particles on the other sides too, but let us consider these two directions only. Obviously each particle attracts another particle with a force directly proportional to the product of their masses, and inversely proportional to the square of the distance between them. Now, if $x>y$ in the above example, the direction of motion will be in the upward direction. Hence, generalizing the statement and taking all the other around it in consideration as well, we can say that the motion of the particle will result in the direction of the resultant of the forces exerted by all the particles.

Similarly, the buoyant force should also be considered as well as the weight and the force of attraction due to the liquid molecules.

HENCE, THE RESULTANT OF THE FOUR FORCES MENTIONED DETERMINES THE DIRECTION OF MOTION OF THE PARTICLE.

We have considered just one particle which has changed its direction owing to the force exerted on it by other particles. Other particles, however, are themselves moving in certain resultant directions because of the forces exerted upon them by the other particles.

Let us consider the particles A and B moving in certain directions owing to the forces exerted upon them. Then, relatively, the distance between the two changes and so does the force exerted upon each other. Hence, the resultant force changes and the particle goes through another change in direction.

Now let us consider a universe in which these particles are moving. Each particle changes its position with respect to every other particle and hence the magnitude of the attractive force changes. For example, if there are molecules and each is moving in a certain direction, the force that one of them exerts upon another changes and so does the resultant of all forces upon a particle. Hence, each particle is moving in a crazy zig-zag fashion relative to all others.

It is, therefore, concluded that every particle influences in determining the line of motion of every other particle, which keeps on changing the line of direction of the other particles around it.

Finally, it can be concluded that :

IN A COLLOIDAL SOLUTION, THE MOTION OF THE PARTICLES TRACES A ZIG-ZAG PATH NOT ONLY BECAUSE OF THE COLLISION OF THE PARTICLE WITH LIQUID MOLECULES BUT ALSO BECAUSE OF THE CHANGING RESULTANT FORCES EXERTED UPON THE PARTICLE BY ALL OTHER PARTICLES, WHICH THEMSELVES ARE IN A SIMILAR STATE OF MOTION, AND BECAUSE OF THE COLLISION BETWEEN THE PARTICLES.

RAJEEV KOHLI

Have You Read These Books ?

In this section in every issue of **School Science** *we will discuss the content of a few books on science. We will place them before our readers, showing that each branch of science is related to another. physics and astronomy/astrophysics merge into one another, which, again, are intimately related to the problem of the origin of life and, therefore, to biology and chemistry.*

The readers will find out themselves a vast continuously growing pattern of relationship between the sciences, if they care to read the books.

In this issue we discuss two books, one on the evolution of physics and another on astronomy.

Read them, if you have not read them already. It does not matter what branch of science you teach or study. It is only by studying other branches of science you can know your own field better.

—EDITOR

ASTRONOMY : Edited by Samuel Rapport and Helen Wright, Washington Square Press Inc., New York (Pocket book, cheap, available in Indian market).

The book brings to the layman a popular introduction to the fascinating field of Astronomy. This excellent collection of essays by leading authorities leads to a tour of the heavens and succinctly describes the precise tools, complex techniques and the astounding achievements of some of the pioneer astronomers and cosmologists of our time. To the early astronomers, the study of Astronomy was, to a large extent, a study of the celestial geography. The book spectacularly reveals the rapid advances in the field of nuclear physics, relativity, artificial satellites and space probes that have greatly aided the understanding of the solar system and Man's place in the Universe. Finally, the spirited selection tends to throw some interesting light on the origin of our universe and about the possibility of existence of life in other "worlds."

PHYSICS : Edited by Samuel Rapport and Helen Wright, Washington Square Press Inc., New York (Pocket book, cheap, available in Indian market).

The book is a beautiful collection of essays by eminent specialists that give the general reader an insight into the exciting world of Physics. Physicists' quest to reduce the apparent complexity of natural phenomena to some simple fundamental ideas and relations are lucidly described. It is shown that the Physics of the eighteenth century had been rather loose and disjointed affair consisting mainly of uncorrelated facts about matter, heat, light, electricity and magnetism; by the close of nineteenth century, these had been correlated and consolidated into a closely knit fabric—the so-called classical Physics. However, during 1895-1900, some cracks in this mighty edifice began to appear in the realms of the extremely large and the extremely small. The book attempts to unfold the complexity of the physicist's world, his passionate dedication to understanding and his single-minded search for unity in the image of the universe. In so doing, it reveals in an exciting fashion, the revolutionary concepts of modern physics used to plug-in the loopholes and highlight the recent achievements aimed at solving the contemporary problems vis-a-vis the dilemmas it faces today.

S. N. Datta

Department of Education in Science and Mathematics

Scientific Terms

Used in This Issue

Agar : *Agar agar*—Any of the various colloidal extracts of certain red algae (as of the genera *Gelidium*, *Gracilaria* and *Eucheuma*) which are similar to each other in appearance. They come in transluscent strips or flakes or white powder.

Physical properties : Ability to swell in cold water and to dissolve in hot water.

Chemically, they are a common type which is essentially a sulphuric acid ester of a linear galactan, occurring as a salt in the cell-wall of the algae.

Agar agar is used in various culture media. They can be used as of dental impression material, as bulk producers in treating chronic constipation and as gelling and stabilizing agents in food (as in ice-creams, jellies, dairy products, canned meat and fish).

Amplitude : The extent of a vibratory movement or of an oscillation. The maximum numerical value of a periodically varying quantity (as an alternating current, a radio wave, the air pressure in a sound field, or the angular displacement of a pendulum) measured from its normal or equilibrium valve taken as a zero.

Anhydride : A compound derived from another compound (as an acid) by removal of the elements of water.

Anther : The part of the stamen (The male part of a flower) containing pollen.

Atom : The smallest particle of an element that can exist either alone or in combination with similar particles of the same or of a different element. It is the smallest particle of an element that enters into the composition of molecules.

Atomic forces : The forces that binds the atoms in a molecule.

Bacterium : Any of a large group of microscopic organisms, having round, rod-like, spiral or filamentous single celled or non-cellular bodies. They are enclosed by a cell wall or membrane. They lack fully differentiated nuclei. The bacteria live in soil, water, organic matter or live bodies of plants and animals, often causing diseases. Some of them are important to man because of their chemical effects (as in nitrogen fixation, putrefaction and various fermentations).

Bacillus : A family comprising of typically rod-shaped Gram positive bacteria that produce endospores. The family includes the genera *Bacillus* and *Clostridium*.

Conduction · Transfer of heat (or electricity) through matter by communication of kinetic energy from particle to particle rather than by a flow of heated (energized) material.

Chromosome : One of the thread-like bodies constituting the genome. Chromosomes are chiefly detectable in the dividing nucleus and are regarded as the seat of genes; they consist of one or more intimately associated chromatids, functioning as a unit and are relatively constant in number in the cells of any one kind of plant or animal.

Colchicine : A poisonous yellow crystalline alkaloid (C—H—NO) extracted from the seed and corn of the meadow saffron. When applied to dividing cells, it may induce polyploidy, an effect used experimentally and commercially to create new plant varieties. Colchicine is also used medicinally in the treatment of acute attack of gout.

Cutaneous : Relating to the skin : existing on the skin or affecting it.

Diameter : A line that bisects each of a system of parallel chords of a curve; the length of a straight line through the centre of an object (or figure or body, e.g., a circle, conic section or sphere, cube, etc.).

Diploid : Double or two-fold in appearance or arrangement, having basic chromosome number doubled; comprising twice the number of chromosome present in a typical sex cell.

DNA : Deoxyribonucleic acid. Any of the various nucleic acids that yield deoxyribose as one product of hydrolysis. It is found in cell nuclei and especially genes and are associated with the transferance of genetic information.

Embryo : An animal or plant in the early stage of growth and differentiation (development).

Fertilization : The process of union of two *germ* cells (sperm and ovum) whereby the somatic chromosome number is restored and a new individual originates in an organism (plant or animal).

Gene · Specific transmitters of hereditary characters, and usually regarded as portions of DNA, linearly arranged in fixed position on the chromosome. They function through the control of the synthesis of specific proteins.

Haploid : Any cell having the number of chromosomes which is half the number of chromosomes of the body cells.

Homozygous : Possessing only one member of at least one pair of allelomorphic characters : producing only one type of gamete with respect to a specified character

Hormone : A specific secretion from the ductless gland. The secretion affects the activity of specific target cells remote from its point of origin

Inoculate · To introduce a live organism either into an organic system, or into a synthetic culture medium. In the former, we introduce a disease to an organism by inserting its causative agent (small-pox germ, for instance).

Insulin : A pancreatic hormone secreted by the islets of Langerhans that is essential especially for the metabolism of carbohydrates. It is commercially obtained in crystalline form usually from beef or pork pancreas, and is used in the treatment and control of *diabetes mellitus.*

Lepromatous : A physical state characterized by the formation or presence of lepromas (a nodular lesion or leprosy); relating to or exhibiting nodular leprosy.

Magnetic field · A region subject to the influence of magnetism It is manifested by the mechanical forces that the field exerts upon electricity moving across it and upon the poles of magnets placed in it.

Pathogen : A specific cause of a disease (usually bacteria fungi, protozeous or viruses).

Polar coordinates : Either of the two numbers that locate a point in a plane by its distance from a fixed point along a line to the point, and the angle this line makes with a fixed line.

Pollen grain : A mass of microspores in a seed plant, appearing usually as fine dust made up of fine grains formed in fours by the reduction of a pollen mother cell. Each grain, consisting of a single cell, has a charactistically structured wall and gives rise, on-germination, to a pollen tube through which its male generative element passes to the ovule for fertilization of the egg.

Ovule : A rounded outgrowth of the ovary in seed plants, which grows into a seed, usually only after fertilization. The seed consists of an embryo sac, borne centrally within nucleus. The nucleus is surrounded by one or more integuments.

Tuberculoid · Resembling tuberculosis, pertaining to a physical state especially in being marked by the presence of tubercles (a rough prominence).

Sucrose : A sweet, water soluble, crystalline, dextorotatory, non-reducing, disaccharide sugar (C–H–O) that occurs naturally in most land plants, especially in the juices, fruits, roots. □

CORRECTIONS

School Science, Vol. 12, Nos. 1-4, 1974

Page 93 Right-hand column under Project 2,
Statement : read $\frac{\pi}{4}$ instead of $\frac{\pi}{2}$

Page 94 Left-hand column, line 6 : read
"Similarly, $\angle$XMY is also a right angle"
line 14 : read area of a circle $= \frac{(\text{diameter})^2}{4}$

Page 95 Left hand column, line 18 : read
25 instead of 15

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COVER : Earthrise from the surface of the moon. Such scenes and the new science of Exobiology have given us a totally new vision of the cosmos (see pp. 18-22).

TO OUR CONTRIBUTORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum of exchange of experience in science education and science projects.

Articles covering these aims and objectives are invited.

Manuscripts, including legends for illustrations, charts, graphs, etc. should be neatly typed, double spaced on uniformly sized paper, and sent to the Editor, **School Science**, Department of Science Education, NIE Buildings, Sri Aurobindo Marg, New Delhi 16. Each article may not normally exceed 10 typed pages.

The articles sent for publication should be exclusive for this journal. Digests of previously published articles modified to suit the scope and purpose of **School Science** will be accepted. In these cases the name of the journal in which the original article appeared must be stated.

Headings should not be underlined.

Selected references to literature arranged alphabetically according to the author's name may be given at the end of the article, wherever possible. Each reference should contain the name of the author (with initials), the title of the publication, the name of the publisher, the place of publication, the volume and page numbers.

In the text, the reference should be indicated by the author's name followed by the year of publication enclosed in brackets, e.g. (Passow, 1962). When the author's name occurs in the text, the year of publication alone need be given in brackets, e g. Passow (1962).

Illustration may be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post-card size, and should be sent properly packed so as to avoid damage in transit.

EDITORIAL

EDUCATION is an inseparable part of life and society; it is a means of transmission of socio-cultural heredity. The approach and content of education in a country has to be consciously determined from time to time to keep up with the changing society.

Now, we have settled for a uniform framework of ten-year school curriculum for the whole country. The need for a uniformity of approach was specially felt for a country like India to remove its innumerable cross currents and caste prejudices, disparate social beliefs and socio-economic conditions along with regional variations in the educational base. Though education remains a state subject, this all-India framework has been prepared through a national consensus. On the eve of wider implementation, now it is time we identify its implication on the responsibility of teachers, the priority the society overtly attaches to its implementation and other requirements for the speedy realization of its aims.

The curriculum framework is a comprehensive and brief document reflecting a reasonable flexibility within the limits of our nationally accepted principles and values. Defining the basic principles and aims of school education, the framework paper provides definite guidelines on the different aspects of the curriculum.

The most prominent feature of the curriculum is its emphasis on the teaching of science and mathematics, and inclusion of health and physical education as compulsory subjects for all the classes. Science, specially the method of science, has been viewed as an intellectual process permeating our daily life and mental activities. Scientific principles are not to be preached as immutable dogmas are taught as abstract concepts. The students should learn science on the solid basis of their own experience.

The role of science teachers, on and off the class, will now substantially change. In fact, the idea about the role of teachers has never been static; it has always been determined by various historical and social factors and even by the individual outlook of the teacher. The changing role and position of the teacher caused by the drastic changes in the social values are responsible for much of their recent frustration and low morale. But it is imperative that school education and, therefore, the concept of the teacher's role should adapt themselves to the changing needs. Contrary to the conventional belief, the teacher in the new situation is not an unquestioned authority in the class, nor should he consider himself as the only source of information. Yet, he is the central figure in the school education. He is to teach his students to learn critically without taking everything for granted. The learning situation is not to be confined to the classroom alone; it has to be extended to the world outside. The teacher is to take care of the cognitive, physical, emotional and creative elements of the process of education. This makes his task wider in scope.

The orientation and training of teachers for the new responsibility and the growing impact of school education, both in intensity and extent, places heavier responsibility on the society also. It requires considerable national effort in terms of men, money and material. If the budgetory provision committed to education is any index, the recent trend shows that our society is unable to bear the burden of educational development even to the extent of the desirable minimum.

In view of the various economic compulsions, drought and flood, restricting our financial ability, the science teachers have to make up for the dearth of equipment by drawing on their own skill of innovation and enthusiasm of the students. Imaginative utilization of the work-experience skill in producing simple science equipment may also be examined.

Streamlining the educational management and revitalization of school administration is another serious task which should be immediately taken up. The effete and indifferent school administration together with the dilatory office procedure often serves no other purpose than to dampen the enthusiasm of the willing teachers.

A need-based curriculum, properly oriented teachers, adequate facilities and efficient administration can only pave the way for an effective science education. □

T. R. Sheshadri : A Profile

1900—1975

THE GOAL of life for some people is leisure and quiet enjoyment of the good things of life. For some, however, the very word 'enjoyment' means ceaseless searching into the mysteries of nature.

Prof. Tiruvenkata Rajendra Sheshadri was a man of the latter kind, and the goal of his life was to find answers to the riddles of the chemistry of plants and to use his knowledge in solving man's problems.

When Prof. Sheshadri passed away on 27 September 1975, we lost an illustrious scientist. But he left many doors opened. The doors were opened to him because he never despaired of knocking on them. He found answers to many riddles of nature, because he faught tirelessly.

Prof. Sheshadri, the third of the five sons of a pious family, was born in a small town Kultallai on the quietly flowing holy river Kaveri, on 3 February 1900. His father was a local school teacher of limited means. Sheshadri had his early education in Srirangam and National College High School, Tiruchirapalli, the ancient religious and pilgrim centre of South India.

At the age of seventeen the young Sheshadri came out of his familiar surroundings to study chemistry at Madras Presidency College under the memorable guidance of Prof. P.A.N. Iyer.

Neither the meagre means of his family nor the scholarship-money which he had always received could sustain him through his education. He could continue his education only with the much-needed support of the Ramakrishna Mission. His stay in the Mission's hostel moulded him into a disciplined, hardworking personality, irreversibly committed to social obligations.

He was initiated into the research in organic chemistry as a university research scholar by Prof. B. B. Dey. His work at this phase consisted partly on Indian medicinal plants and partly on coumarins which got him the award of two research prizes from the Madras University.

In the next phase of his life we see him wandering in the higher centres of chemical research and the laboratories of the west. Helped by the Madras Government, he went to Manchester to work under Sir Robert Robinson, a Nobel Laureate, and followed the latter to the University College, London. He received his doctorate in 1929 from the Manchester University for his search for new Antimalarials and the synthesis of Anthocyanin.

His wanderings brought him to the famous centres of chemical research in Switzerland, Germany and Austria where he came into contact with the famous workers in the field. He worked in the laboratories of a Fritz Pregel, Nobel Laureate, in Austria on organic micro-analysis and with George Berger, F.R.S., on alkaloid and retrosine. He acquired the techniques of agricultural analysis under Mr. Cameron and returned to India in 1930 as a full grown organic chemist.

His career, as an independent investigating scientist in this country, was full of struggle, sacrifice, determination, success and glory.

With all the best foreign training as his background he declined offers of more lucrative jobs and worked in the Madras University as a mere Research Fellow and later as a Research Officer in the Agricultural Research Institute, Coimbatore. Here he got the first-hand knowledge of the various aspects of agricultural sciences like plant protection and plant chemistry. In Coimbatore he first started his work with plant pigments which he pursued almost throughout his life.

In the year 1933 Dr. Sheshadri joined the newly started Chemistry Department of the Andhra University, Waltair, as its Head. First as a Lecturer and subsequently as a Reader and Professor, he built up simultaneously two departments: Chemistry and the Chemical Technology and Pharmacy and continued his own research work in a faraway laboratory at the Andhra Medical College, covering the long distance on a bicycle.

But soon the Second World War broke out and the aerial bombing of Vishakhapatnam disturbed the physical and academic tranquility and tended to disintegrate Dr. Sheshadri's research centre. The laboratory was temporarily shifted to Guntur and then to Madras. Even against these heavy odds Dr. Sheshadri and his students could publish about sixty research papers.

In June 1949, Prof. Sheshadri was invited to head the Chemistry Department of the Delhi University. Here as the administrative head of a department consisting of more than a thousand students of both degree and post-graduate courses and a vast research laboratory he showed astounding ability and stamina.

As a teacher, Prof. Sheshadri was a master in the art of teaching.

He had taught his students not only in the art and techniques of chemical investigation but also inculcated in them the highest virtues of life.

Prof. Sheshadri's researches in the chemistry of natural products extended over more than four decades and his contributions are varied.

However, his most outstanding contribution is in the field of plant colouring matter, which he pursued throughout his life. Starting from the pigments of cotton flowers he studied other plants of the Malvaceae family in order to find out if there was correlation between the botanical classification and chemical composition.

He and his collaborators chemically isolated and determined the structure and synthesized numerous plant compounds.

The second most important area of his interest is the plant polyphenols (other than colouring matters). These relate to compounds which are important for durability and resistance to attacks by insects and micro-organisms, astringency properties of edible materials and seeds), tanning properties of vegetable tannins and development of colours of fruits. He studied a large number of plant products of economic importance, related to sylvicultural and horticultural interests.

Medicinal plants and plant products of economic importance always had high priority in Sheshadri's interests. He isolated and probed into many compounds of Indian medicinal plants.

Professor Sheshadri was a pioneer in the field of chemical studies of the lichens. These plants are natural symbionts—biological chimera of two plants, one belonging to the Algae and the other to the Fungi groups. The litmus indicators are made from the lichens. His researches in this field have led to the discovery and synthesis of many new compounds. He also suggested useful control measures for the lichens which cause considerable damage to sandal trees and ancient monuments.

During his long active research and teaching career he had trained about 160 students for doctoral degrees.

Honours have been showered on him. He had been conferred honorary doctorate degrees by the universities of Andhra, Banaras and Osmania and was an Honorary Professor of Andhra and Osmania universities. He was awarded the Acharya P. C. Ray Medal and Bhatnagar Medal. He was the President of the Indian Science Congress, the National Institute of Sciences, the Indian Chemical Society, the Indian Pharmaceutical Association, the Indian Pharmaceutical Congress, and the Oil Technologists Association of India. He was an Honorary Fellow of the Deutsche Akadamic fur Naturforsches (Helle) and a Fellow of the National Academy of Science.

He had received the Indian state honour of Padma Bhushan and was among the few Indians who had been nominated as the Fellow of the Royal Society (London).

Prof. Sheshadri was a rare inexuberant Indian who rose to a prominent place in science, simply through toil, dedication, unquenchable thirst for knowledge and deep love for humanity. ☐

— D. L.

Development in Science Education

B. GANGULY

Professor, Department of Education in Science and Mathematics, NCERT, New Delhi

SCIENCE EDUCATION today is a discipline in itself. In the last fifteen years a number of journals on science education have come out, and innumerable research papers have been published. These research findings reflect the extensive intellectual pursuits in this area. The works on science education may be broadly divided into two groups : (1) Development of Curriculum and (2) Development of Research Findings. Such division, however, is artificial, and can be done for the convenience of discussion. In reality, both these components are interdependent and they developed simultaneously.

DEVELOPMENT OF CURRICULUM

The development of curriculum has three components : (i) Production of Instructional Material, (ii) Implementation, and (iii) Evaluation. Today, almost all the countries have produced instructional materials for improved teaching of science at the school level. Both the developed and developing countries felt that in order to live fruitfully in tomorrow's society and for their economic progress, it is essential that children should be acquainted with science from the initial stage of school. In order to attain this objective, different instructional materials, i.e.syllabus, curriculum guide, textbook, teachers' guide, workbook, laboratory manual, kit, kit-guide, film and different audio-visual aids have been produced. Different kinds of approaches, e.g. discipline-wise, integrated, environment-oriented, general science, etc. have been followed. At the initial stage some countries preferred to follow the materials developed in the advanced countries ; but soon it was realized that the social needs of different countries are different. Therefore, the instructional materials should be shaped according to those specific needs. The other factors which, together with specific needs and aspirations of the country, influenced the pattern of instructional materials are the contemporary growth of knowledge, availability of suitable functionaries in the country and development of those materials in other countries. All these factors together form the curriculum climate for the production of instructional materials.

The success of a new curriculum depends on how effectively the different factors which influence its implementation are dealt with. The four factors and the usual steps followed are given below.

A. Knowledge and awareness of the educational administrators. Educational *administrators* involve a wide range of people in the Education Department, in the Board of Education and Principals in the schools. Through orientation programmes, such people are convinced about the new curriculum. Main emphasis is given on those aspects through which they can create a proper atmosphere in which the teachers can effectively give shape to the curriculum. Their role includes planning,supervision and guidance.

B. Knowledge and attitude of the teacher. The teachers are the most important functionaries in giving shape to the new curriculum. Through pre-service and in-service training programmes, the teachers are taught about the contents, different methods and philosophy of the curriculum. For this purpose training programmes are also organized for the method masters and science educators. As the new science curriculum proposes extensive laboratory work, the training of laboratory technicians are also arranged to provide effective assistance to the teachers.

C. Facilities available in the school. New science curriculum demands considerable material requirements for its proper implementation. Such requirements include organization of classrooms, arrangement of routine, setting up of laboratories, availability of equipment and chemicals, keeping of living animals, school garden, facilities of field work and scope of doing various out-of-school activities. Most of these requirements are to be met through improvization. Such improvization is possible through combined imaginative efforts of school administration and the classroom teachers.

D. Social conditions. A student lives in two kinds of distinct environment : the school and home. Learning can be effective only when these two environments are complementary to each other. While introducing any new curriculum to the school, it is necessary to communicate the same to the society, so that least confrontation is created. The parent-teachers association, community lectures and different mass-media are the best channels used to communicate the new curriculum to the society.

The third component in the curriculum is evaluation. Evaluation may be formative and summative. The formative evaluation accompanies each step of production and implementation. It reveals relevant information about the curriculum climate, identification of the facilities available, selection of objectives, selection and presentation of the contents. On one hand, the formative evaluation makes the instructional materials realistic, and on the other, it identifies various factors which are to be taken care of during the phases of implementation. The evaluation during each step of implementation, brings out the weak points which may be corrected accordingly. The summative evaluation judges the student's achievement and the findings lead to the revision of the materials. However, the following nine steps are usually involved in any kind of evaluation.

1. Analysis of examination results.
2. Assessments of teachers on some parts of the courses.
3. Teachers' feedback on chapters.
4. Questionnaire asking for teachers' opinion on achievement or on the objectives.
5. Comments by the students.
6. Consensus of the conferences of teachers and other science educators.
7. Reports from area meetings of the teachers.
8. Visits to the schools by external ovbserers, area coordinators and the project organizers.
9. Content analysis by competent persons who are outside the project.

The results of all these steps are combined to arrive at the final conclusion.

DEVELOPMENT OF RESEARCH FINDINGS

Science education, as it is seen today, started in the late fifties of this century when a group of scientists and pedagogists assembled in the Marine Biological Laboratory, Woods Hole, U.S.A., to determine a suitable mechanism by which the profusely growing scientific knowledge can be effectively taught to the future generation. The discussion resulted into the formulation of a theory which is known as the theory of curriculum development (Bruner, 1960). According to this theory, each discipline of science has certain elements. These elements are to be arranged meaningfully to form a structure. The students are to understand this structure through different methods. This understanding would help the student to realize the concepts and principles of the discipline in greater breadth and depth.

For the following four reasons, the theory of curriculum development was widely accepted.

1. As it is concerned with the objectives of the cognitive domain, it is easier to prepare printed instructional materials.

2. It is easier to train teachers, because training involves only content enrichment.
3. Is is possible to take an account of the teachers' performance.
4. It fits well with the various learning theories (Piaget, Bruner and others).

The first model which was developed according to the theory of curriculum development was known as "content-oriented model". According to this model content was considered as the most important aspect, and once the content is fixed, all requirements of implementation should follow. This was later replaced by Tyler's model (School Council, 1967) which suggested that discussion of content is to be linked with the process by which it has developed. It proposed three stages: (1) The determination of objectives, (2) Devising and trying out of the methods achieving the objectives, and (3) Evaluation of the effectiveness of the methods.

These three stages of Tyler's model were further extended by Wheeler into the following five related and cyclical stages (1967).

1. Selection of aims, goals and objectives.
2. Selection of learning experiences calculated to help in the attainment of the aim, goals and objectives.
3. Selection of content (subject-matter) through which certain types of experiences may be offered.
4. Organization and integration of learning experiences and content with respect to the teaching-learning process within the school and classroom.
5. Evaluation of the effectiveness of all aspects of phases 2, 3 and 4 attaining the goals (stated in 1).

An important change took place at this stage of curriculum development. Richard Jones (1968) attacked the theory of curriculum development for its over-emphasis on the objectives of cognitive domain. He pointed out that during implementation of a curriculum the teachers remain so busy in teaching the content that they often have no time to give individual attention to the students. Individual attention is essential for developing scientific attitude and other objectives which belong to the affective domain. This view obtained tremendous support from various workers who blamed the theory of curriculum development for giving unnecessary emphasis on content and thus encouraging a kind of "mindlessness" in teachers which does not fulfil the true purpose of education.

As opposed to the theory of curriculum development, Jones forwarded the *theory of instruction.* According to this theory, the most important thing is *how* the subject is taught and not *what* is being taught. In order to implement a curriculum a teacher must know different methods to teach different kinds of students in the same class. He must have self-reliance for motivating all his students in the class. He must know that his lesson plan is not the end, but the means of teaching the student.

The impact of the theory of Jones was so great that the proponents of the theory of curriculum development had to modify their views (Bruner, 1972). It was accepted that in the teaching of science both the content and instruction are equally important. While determining the content, it is necessary to consider all the factors which will influence its effective instruction.

The view of Peter and Hirst (1974) have added new dimension to the philosophy of curriculum development. According to Peters and Hirst, each student has his own way of learning and each one of them has the right to learn. Moreover, too much emphasis to prepare the students to fit into the existing needs of the society may lead to the blocking of individual potentialities. The maintenance of individual potentiality is urgently required to bring the desired changes in education system.

With the inclusion of all these intricate deliberations, the planning of science education in different countries have undergone radical changes. What would be the shape of the science curriculum? What should be the breadth and depth of the content for each level ? What should be the methods to teach the content effectively to all students ? The answers to these questions are coming up through research studies. Such studies are being made on *laboratory organization, teaching of specific topics, use of alternate method of teaching, language for presentation of textbooks, improvization and use of equipment, techniques and audio-visual aids and preparation of the proper tools for evaluation.* Emphasis has been laid on the training of all the functionaries : method masters, science educators, teachers and laboratory technicians. The reason behind this emphasis on training is the result of the realization that whatever may be the shape (be it discipline-wise, integrated, general science or environment-based) of the curriculum, its success depends upon the teachers. The teacher should not only be *trained* but should also be properly *equipped* and the necessary *environment* should be created for his proper functioning. Significant research studies have been made on different aspects of implementation. Research findings which have come out in the area of evaluation have helped in strengthening the curriculum. Intensive efforts are being made to devise suitable tools of evaluation and their use in the development of curriculum.

SCIENCE EDUCATION IN INDIA

The development of science education in our country started almost at the same time with those in other countries. The leadership to this work was provided by the National Council of Educational Research and Training, New Delhi. The main task ahead at the initial stage was to create a *curriculum climate* and to identify a group of enthusiastic *functionaries* who will effectively participate in all the three components of the development of science education : *production*, *implementation* and *evaluation*. Despite financial limitations growing number of students, and cultural diversity of the population, considerable progress has been made since the mid-sixties. Throughout the country, even in remote rural areas, the importance of science education has been understood. The people have been made aware of the need of a proper science education and a confidence has grown that they themselves can improve it. In all the states, a definite instrument with trained personnel has been developed to gear up the task of developing science education. A working group, consisting of university professors, college lecturers, research scholars, method masters and classroom teachers, is now available in all the states, helping the state functionaries.

In doing this task, the NCERT, in collaboration with the Unesco / Unicef, has produced various instructional materials for primary, middle, and partly for secondary levels in the 11-year school pattern. The production of such instructional materials demanded the involvement of representations from all states and people from varied professions. This gave the materials a true national character and they have been eagerly adapted or adopted by all the states.

In the implementation part of the work, the NCERT has organized training programmes for the personnel in the states and has also provided them with expertise for the training programmes organized by the states. The summer institutes are organized every year to train the teachers. The kits developed for the teaching of science have been distributed to various schools. The Science Talent Search Project identifies the gifted students. The programme of National Science Exhibition has created a nationwide movement towards the cultivation of scientific activities.

In spite of the effective pioneering work, it must be admitted that negligible research studies have been made in any of the three areas of the development of science curriculum. For this reason, we have not been able to make substantial improvisation in the development of instructional materials. Research studies are needed in different areas like teaching of particular topics, preparation and use of improvised equipment, techniques and teaching aids, classroom organization, and learning abilities of concepts. Regarding implementation, we do not know what are the factors and how they affect the diffusion of training. The bio-social aspects of education must be properly identified without which the curriculum can never be made effective.

The evaluation should be considered as an integral part of the curriculum development. It should also be taken up as a subject of research studies to find out specific problems and to offer their solutions. Such research studies alone can eliminate the weaker points of the curriculum development. The research studies as an integral part of the development of science education are required in our country, particularly when we are making attempts to introduce science as a compulsory subject in the first ten years of school education. Its objectives, as outlined in the approach paper (NCERT, 1975), will never be fulfilled unless we clearly resolve where and how we are going to introduce this curriculum. Systematic research studies alone can provide us with the answer. ☐

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A Theorem on Right-Angled Triangle

PITAM SINGH

> *If all the sides of a right-angled triangle are of the form a, or b,c (where a,b,c are non-zero whole numbers) then we can find all the sides of the triangle by the knowledge of only the product of sides including the right angle without using Pythagoras Theorem by the following method.*

LET the product of two sides including the right-angle of a right-angled triangle be A. Now we search for four whole numbers P,Q,R and S such that :

$$P+Q+R+S=A/2$$
$$PQ=RS$$

and, $P-Q=R+S$

Now, $P-Q$ or $R+S$ will be the hypotenuses and $P+Q+R+S$, the perimeter of the right-angled triangle.

Example 1 :

Let the product of sides including the right-angle is 60. We find four numbers P,Q,R,S such that :

$$P+Q+R+S=30$$
$$PQ=RS$$
$$\text{and, } P-Q=R+S$$

These numbers are :

$$P=15,\ Q=2,\ R=10,\ S=3$$

Hence the hypotenuses of right-angled triangle will be $P-Q=R+S=13$ and perimeter will be $P+Q+R+S=30$. Hence other two sides will be 12 and 5.

Example 2 :

Let the product of sides including the right-angle is $\frac{60}{49}$ In this case, the four required numbers will be the following :

$$P=\frac{15}{7},\quad Q=\frac{2}{7},\quad R=\frac{10}{7}\quad \text{and}\quad S=\frac{3}{7}$$

In this case :

$$\text{Hypotenuses} = \frac{13}{7}$$
$$\text{Perimeter} = \frac{30}{7}$$

The other two sides of the right-angled triangle are $\frac{12}{7}$ and $\frac{5}{7}$.

Remark :

The determination of the numbers P,Q,R and S is done by trial and error method. It can be easily done by the method of factorization.

Some times it may be difficult to find the desired numbers P,Q,R and S. In such cases we multiply numerator and denominator in half of the product by a whole number and repeat the process till we get the desired numbers.

For Example, we are given the product to be 30. The half of the product is 15. It is not possible to choose the desired numbers P,Q,R, and S.

By multiplying the numerator and denominator by 2 we get $\frac{15\times2}{2}=\frac{30}{2}$. Now four numbers will be the following.

$P=10$, $Q=3/2$, $R=6$ and $S=5/2$.

Hence hypotenuse is $\frac{17}{2}$ and perimeter is 20. The other two sides of the triangle are 4 and $\frac{15}{2}$.

Method to Find Out P, Q, R, and S

Let the given product is 48. We first find out those pairs of whole numbers whose product is $\frac{48}{2}=24$. In this case they are the following :

(1,24), (2,12), (3,8) and (4,6)

If among the above pairs we choose first pair for the purpose i.e., take $P=24$ and $Q=1$. Then $P-Q=23$. In the remaining pairs there is no pair which has numbers whose sum is 24. So, we will not take $P=24$ and $Q=1$. Now consider the pair (2,12). Take $P=12$ and $Q=2$. So difference $P-Q=10$. Now in the remaining pair there is a pair (6,4), the sum of whose numbers is 10. Hence we can take :

$P=12$, $Q=2$, $R=6$, and $S=4$

Below we give a table, in which we have taken different product and calculated the sides of right-angled triangles formed by those products.

NUMBER TABLE

S.No.	*Product*	$\frac{\textit{Product}}{2}$	*(P,Q)*	*(R,S)*	*Hypotenuse*	*Perimeter*	*Sides*	*Remarks*
1.	12	6	6,1	3,2	5	12	5,4,3	
2.	60	30	15,2	10,3	13	30	13,12,5	
3.	120	60	20,3	12,5	17	40	17,25,8	
4.	420	210	35,6	14,15	29	70	29,21,20	
5.	48	24	12,2	6,4	10	24	10,8,6	
6.	240	120	30,4	20,6	26	60	26,24,10	
7.	1680	840	70,12	28,30	58	140	58,42,40	
8.	1080	540	60,9	36,15	51	120	51,45,24	
9.	480	240	40,6	24,10	34	80	34,30,16	
10.	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{2},\frac{1}{4}$	$\frac{3}{4},\frac{1}{2}$	$\frac{5}{4}$	3	$\frac{5}{4},\frac{3}{4},1$	
11.	$\frac{12}{25}$	$\frac{6}{25}$	$\frac{6}{5},\frac{1}{5}$	$\frac{3}{5},\frac{2}{5}$	1	$\frac{12}{5}$	$1,\frac{3}{5},\frac{4}{5}$	
12.	$\frac{48}{25}$	$\frac{24}{25}$	$\frac{12}{5},\frac{2}{5}$	$\frac{4}{5},\frac{6}{5}$	2	$\frac{24}{5}$	$2,\frac{8}{5},\frac{6}{5}$	
13.	$\frac{20}{3}$	$\frac{10}{3}$	$5,\frac{2}{3}$	$1,\frac{10}{3}$	$\frac{13}{3}$	10	$\frac{13}{3},4,\frac{5}{3}$	

The Micropill that Puts Drugs on Target

JOHN NEWELL

By incorporating drugs in minute droplets of oily compounds for injection into a patient's vein, and coating the droplets with specific antibodies and chemicals, it may be possible to direct them accurately to the organs or tumours for which they are intended without affecting the rest of the body.

Since the cell concept, the greatest unifying principle in modern biology, is included in our school syllabi, our readers may find the following article useful.

All the expressions of life : the structure and function, the process of diseases, cure or death are cell-based. The article describes a trend in modern researches on the complex problem of drug administration in cellular diseases like cancer. Our understanding of the mechanism of cellular activity is leading us to the cures for such diseases. The classroom teacher, while teaching the different areas related to the cell, may use the information in this article to illustrate his ideas.

—Editor

AN ACCURATE TECHNIQUE FOR TREATING FORMS of cancer, enzyme deficiency diseases and some infectious diseases is promised by the work of doctors at the Clinical Research Centre of the UK's Medical Research Council. The technique has been developed over several years by Dr. Gregory Gregoriadis, his colleague Dr. Brenda Ryman and others, first at the Royal Free Hospital in London and then at Northwick Park Hospital near Harrow, where the Clinical Research Centre is situated. It involves incorporating drugs in what have been nicknamed *micropills*, minute droplets of oily compounds properly called *liposomes*, and then injecting these liposomes into a patient's vein.

Liposomes have been used in the treatment of human cancer and human enzyme deficiency diseases for the first time recently. They will soon be used clinically for another purpose, to make vaccines more effective in protecting against diseases. Other uses are foreseen. The research team at Northwick Park are now trying to make liposomes even more effective as drug-delivery systems, by coating their surfaces with antibodies and chemicals which will direct the liposomes specifically to the tissue where the drugs they contain are required, without affecting the rest of the body at all.

Spherical Droplets

Liposomes are remarkably simple to make. It is done by drying *phospholipid* compounds and then adding oil-soluble drugs that are to be incorporated in the liposomes. Then water is added together with any drugs required which dissolve in that. Finally, the mixture is subjected to powerful, high-frequency sound waves that emulsify it. The result is that the mixture separates into tiny, spherical droplets, each one, with an onion-like structure of several concentric shells, consisting of alternate layers of phospholipid and water. By altering the ultrasound frequency the size of the liposomes formed can be changed, more or less at will, to any size from only 100 A in diameter up to that of a bacterium.

Finally, a solution containing liposomes, carrying the appropriate drug, is simply injected into a vein with an ordinary hypodermic syringe. A liposome reaches its target via the bloodstream like an ordinary injection, or like the contents of an ordinary swallowed pill after it has been digested and absorbed into the bloodstream from the digestive tract.

But the liposome has three substantial potential advantages over ordinary injections or pills. First, a single liposome can carry either water-soluble or oil-soluble drugs, or even both together. This means that a single injection may do several different therapeutic or prophylactic jobs.

Second, although its cargo may include potently reactive and even toxic compounds, the liposome presents a bland, inert facet to the bloodstream in which it travels. The reactive drugs are inside it, out of harm's way. The white cells patrolling in the blood, which are immensely sensitive to any foreign compounds introduced into the circulation, are no more aroused by liposomes than they are by the fatty droplets which are continually carried by the bloodstream to the liver from the absorptive section of the gut. Only when brought into contact with the appropriate cell membrane structures are liposomes incorporated and ruptured to release their load of drugs.

Third, experiments have already shown that it is relatively easy to coat the surface of a liposome with antibodies which react specifically with, and only with, antigens on the surface of particular cells or organs.

It is as though liposomes coated in this way possess keys which fit locks only in certain cells. Cancer cells are well known to have specific surface antigens, not found in any normal cells. Experiments are already in progress to make liposomes into 'guided missiles', aiming at cancer cells by coating them with anti-cancer antibody. It is also believed, though this work is less advanced, that the different organs of the body, such as the liver, have organ-specific antigens on the surfaces of their cells. So, theoretically, it should be possible to direct liposomes accurately to target organs as well as to tumours. This technique means that much higher doses of toxic drugs than those used today may be used in the treatment of cancer or infection, because only the target or, at any rate, mainly the target area, would be affected by the drug.

Delivery to Target

Liposomes are already beginning to 'home in' on tumours. They are being used to carry the anti-cancer drug Actinomycin D, an antibiotic which suppresses cancer cell division, to the sites of tumours. In the first trails, liposomes carrying the harmless protein compound albumen were used. The albumen was made slightly radioactive to check its route in the body, and it was found that, even without any treatment of the surface of the liposomes, the tumour tissue took up substantially more of the albumen than the surrounding tissue did. In the case of one kind of tumour of the kidney, the tumour actually absorbed fifty times as much albumen as did equivalent volumes of surrounding healthy tissue.

These results were so encouraging that they have led swiftly to the first clinical trials of liposomes as drug carriers. Dr. Gregoriadis and his colleagues find three reasons why, even without surface 'targetting', liposomes still deliver more drug to tumours than to normal tissue. First, tumour cells tend to incorporate any compatible particles more readily than other cells. Second, once absorbed, the phospholipids are broken down more easily in cancer than in normal cells. Third, tumours acquire rich blood supplies, which will tend to bring more than the average share of circulating liposomes to a tumour.

Dr. Gregoriadis and Drs. Brenda Ryman and Rosemary Buckland have also brought liposome therapy to the point where it is ready to be used clinically for the treatment of what are called storage diseases. These are conditions in which genetic abnormalities lead to the enzyme deficiencies in living cells. If these enzymes are among those concerned with the breakdown of waste products and metabolic by-products, then their absence means that the unwanted chemicals steadily accumulate in minute bags called *lysosomes*, not to be confused with liposomes, inside the cell.

Research has now shown that the missing enzymes can be delivered right into lysosomes in liver cells after which the inserted enzymes will dispose of the by-products mounting up.

Liposomes are surrounded by the same sort of oily sheath which forms the wall of lysosomes, so they find their way naturally to the area inside the cells where the enzymes are required.

In their first trials, Gregoriadis and his team showed that the liposomes successfully found their way to lysosomes in the livers of experimental rats and delivered their enzymes. Next, they showed that the same thing happened with human cells, this time using a well-known enzyme, *invertase*, and cells in tissue culture. The first cautious trails are due to begin on human patients.

Meanwhile Dr. Anthony Allison, head of the cell pathology department of the Clinical Research Centre, working with Dr. Gregoriadis, is developing yet another use for the liposome, which looks as though it will very soon be ready for clinical trials. This is a means of increasing the efficiency of vaccines.

Various substances called *adjuvants* are already used to do this. For example, diphtheria and tetanus bacterial proteins, and protein coat material from some viruses, can be made much more effective in stimulating immunity by the addition of mineral oil and other bacterial material. But adjuvants of this kind, while useable in animals, are unsuitable for humans because of the undesirable reaction they promote around the site of injection. Vaccines made into liposomes and used in tests with mice and other animals have produced a much higher level of immunity than the vaccine material on its own, with no harmful side effects.

The effect of liposomes is so marked that they are being rapidly developed to use as adjuvants, though the reason for their effect is still not fully understood. But the liposomes tend to be directed to lymph nodes where *macrophages* or scavenging white cells also congregate, so it may be the greater contact with these immunity-producing cells that is responsible for the liposomes' effect.

Dr. Allison sees three historic stages in the development of liposomes. At first, they were an experimental device for the study of the permeability properties of double lipid layers. Then they were used in laboratory research as a means of introducing various chemicals into cells, to see what effects they had. But now getting under way and heralding something perhaps important enough to be called a medical revolution, is the clinical phase. This will begin when specific routing of liposomes to organs and tumours, so far achieved only experimentally, is achieved clinically too.

Dr. Gregoriadis sees still more clinical uses for liposomes emerging in the not too distant future. The enzyme replacement research has already shown that liposomes can reach liver cells. So drugs to treat all sorts of liver diseases could be delivered. Antibiotics in liposomes are being used in cancer treatment, so why not deliver them in the same way to inaccessible parts of the body where bacterial infections are hard to eradicate by conventional means? Antibodies, the human body's own chemical weapons against viruses and bacteria, might be delivered to parts of the body specially in need of reinforcements after being mass-produced and concentrated outside.

Even genetic engineering may be reached with the aid of liposomes. For this, a liposome would have to be designed to deliver its cargo, in this case DNA, the correct version of a defective or deficient gene, to the nucleus of a cell and not merely through its outer membrane to the cytoplasm. More elaborate liposome 'tailoring' might be necessary. But the possibility of curing genetic disease with DNA encapsulated in liposomes is real. □

Temperature and Altitude

L. D. AHUJA

Chemistry Department, Indian Institute of Technology, New Delhi

THERE IS A COMMON BELIEF THAT TEMPERATURE falls as the height of the atmosphere increases. This belief is borne out by the everyday experience of people going to mountains which are definitely cooler than the plains. There are several reasons for this decrease of temperature with altitude, the most important being a decrease in the density of gases and the absence of dust particles in these regions.

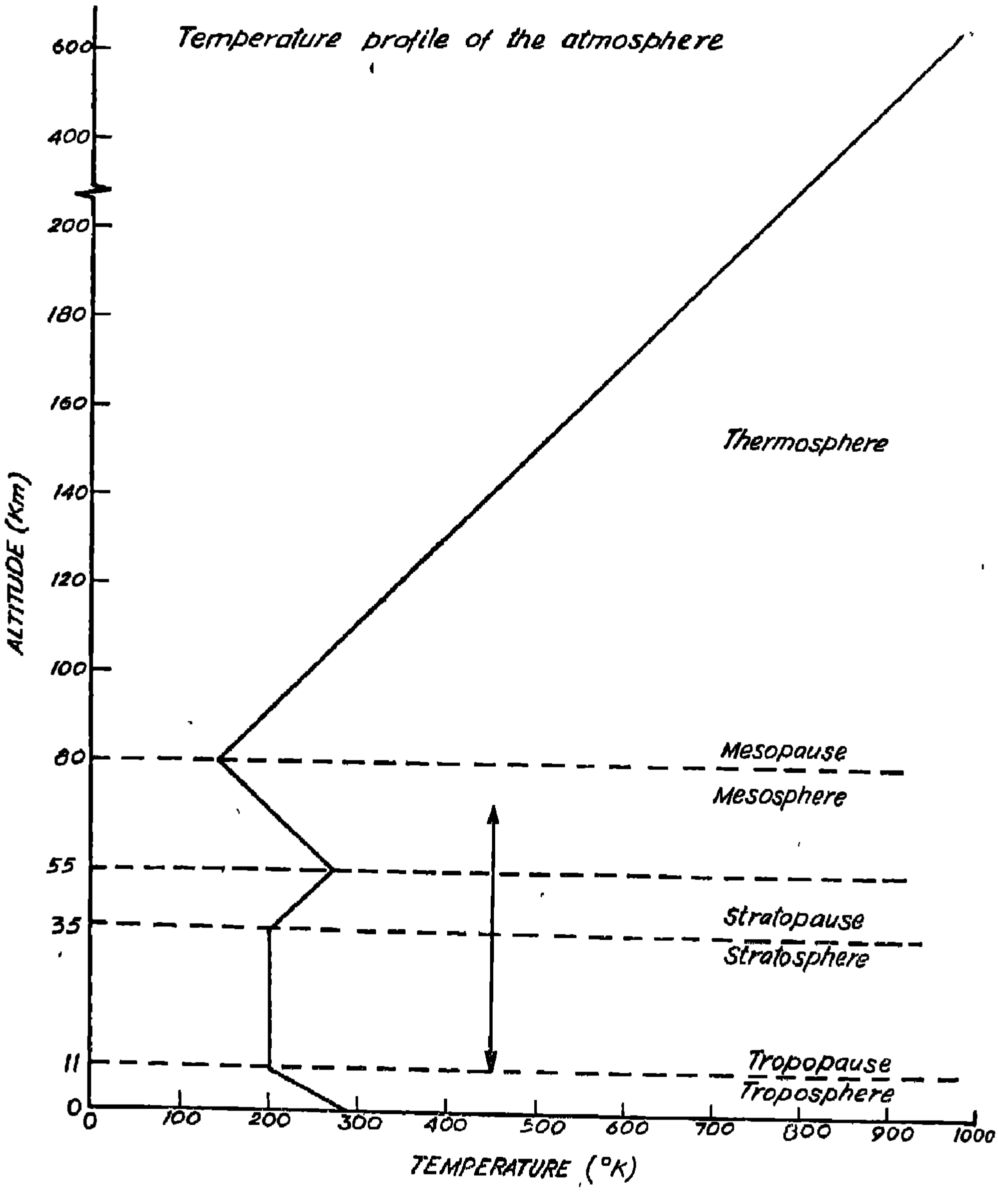
The above picture is true mainly for *troposphere* which extends to an altitude of 11 km or less. It is this region which is of greatest significance for us since it contains the air we breathe and the air in which all weather processes occur.

Troposphere is followed by *Tropopause*, a region in which the temperature remains constant at about—70°C up to an altitude of 35 km; beyond this region the temperature starts rising once again and reaches 30°C. The rise in temperature in this region is due to the absorption of ultra violet and infra red radiations from the sun by ozone. This region is called *Stratosphere* and ranges from 35 to 55 km. Fortunately, the rate of exchange of material from *stratosphere* to *troposphere* is slow.

The concentration of ozone decreases rapidly with height resulting in a decrease of temperature ultimately going down up to—200°C. This region is called *stratopause* and is followed by *mesosphere* and *mesopause*. The limits of these three regions are 55-80 km.

The fall in temperature is then followed by a continuous rise in temperature reaching 500°C at about 200 km and exceeding 1000°C at the upper boundary of 700-800 km. This region is called *thermosphere*. The temperature increase in this region is due to the absorption of solar ultra-violet radiation by molecular oxygen and nitrogen. The air in this region becomes ionised under the influence of solar of radiations. It is these ionised particles which are responsible for reflecting radiowaves.

The following graph gives a pictorial representation of the temperature variation in the various regions already mentioned above.


Temperature profile of the atmosphere
ALTITUDE (Km)
600
400
200
180
160
140
120
100
80
55
35
11
0
TEMPERATURE (°K)
0
100
200
300
400
500
600
700
800
900
1000
Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere

The Science in Science Fiction

In this issue we attempt a probe into the scientific basis of a story *The Black Cloud* written by the celebrated astrophysicist Fred Hoyle. Since the enjoyment of the book depends upon a working familiarity with the scope of a new science – Exobiology – a short note "What is Exobiology ?" is given below.

Equipped with this basic information, the reader may get into Fred Hoyle's world of fantasy which follows the note.

FRED HOYLE (1915–) is a British astronomer and astrophysicist, educated at Cambridge where he started teaching astronomy and experimental philosophy in 1958. His numerous radio talks and such science fiction as *The Black Cloud* (1957) and *Ossian's Ride* (1959) have earned him a popular reputation. He is noted for his theory of 'continuous creation' and such books as *The Nature of the Universe* (1950) and *Frontiers of Astronomy* (1955).

His name is now more widely known in India because of his collaboration with the Indian scientist J. B. Narlikar.

In the article that follows the note below, there is a reference to Blaise Pascal. Who was he ?

BLAISE PASCAL (1623-62), a French experimental and theoretical scientist, who contributed to many fields of scholarship. His works on problems of vacuum and atmospheric pressure helped the invention of barometer. His experiments established the Hydrostatic principle that liquids and gases at rest transmit equal pressure in all directions. This principle has practical application in the hydraulic press. He also invented a calculating machine.

Hydrostatics is a branch of mechanics concerned with the pressure exerted by liquids and gases.

Religious controversies between him and others le to his retirement from scientific studies and experimentations. During his retirement he put down his religiou beliefs with a view to improving the morals of Parisian youth. These writings were published as *Pensees* in 1670.

—EDITOR

What is Exobiology ?

A billion suns in our own galaxy, and beyond it, perhaps, there are a billion galaxies. Should life appear only on the surface of an unimportant planet circling round a second-rate star ? Are we alone in the Universe ? These questions now loom larger than ever. The laws of probability suggest that there are not less than 200,000 and not more than 800 million life-bearing planets in our galaxy.

And out of these questionings and reasoning was born EXOBIOLOGY—a new science.

It was about a decade and a half ago that Joshua Lederberg, a Nobel Laureate and a versatile biologist, coined the term exobiology for the study of life in other planets, i.e. the extraterrestrial life.

What a world of strange phenomena may we not discover if we examine the alien dust of a far-off planet ! What unheard sounds may we not hear if we translate the radiowaves from a distant galaxy ? What hidden knowledge may we not stumble upon if we could probe into the chemistry of life's origin in other planets : An exobiologist searches for any pre-biotic chemical evolution in other planets, or tries to find out the missing links in the formation of life on the earth or whether life in some planets is in an advanced stage of evolution compared to ours.

"Pre-biotic chemical evolution"—does it sound a bit unfamiliar ? We are coming to that soon. Meanwhile, we accept that the earth is not the sole abode of life. Experiments show that complex organic compounds can be artificially synthesized in simulated atmosphere of the primeval earth. This, to the exobiologists, is a piece of strong evidence, implying that life may arise under suitable conditions on other planets.

Life is the result of one of the multiple branches of evolution of matter. The uniqueness of life lies in the specific routes of its appearance and perfection. These routes, which led to the origin of biological organization, represent the pre-biotic stages of chemical evolution. So far we have known life by one single example : the terrestrial life, that is, the kind of life forms that appear on this planet. Hence, the earth and the events which took place on it, to a considerable extent, must have followed a pattern similar to the origin and development of life elsewhere in the Universe.

However, empirical studies in exobiology await a wider development of technology for manned space flight and for the return of planetory samples to our laboratories. The data hitherto obtained suggest that the conditions on Venus may be compared with the conditions that existed on our planet many million years ago, and those on Mars are perhaps similar to those that will prevail on the earth many million years hence.

Exobiology, however, will not always remain a science in search of a subject. If life is discovered elsewhere, it will be an event of scientific and cultural importance. If extraterrestrial life is not found in the solar system, the exobiological studies will merge with the understanding of the history of the solar system—a history in which the origin of life on our planet was a momentous event.

UTPAL MALLIK
Lecturer in Biology, Department of Education in Science and Mathematics NCERT

THE BLACK CLOUD

Fred Hoyle's *The Black Cloud** tells the story of a gigantic Cloud and its effect on the earth. The cloud is coming in the direction of the solar system and it is realized by the astronomers that its passage could cause serious trouble for life on the earth. The governments plan to avert any possible disasters by setting up scientific establishments all over the world. One such group (in Great Britain) has a shrewd theoretical astronomer at its head and he can bargain for himself freedom from military and political control. Scientific egg-heads from different parts of the world can be collected and they prove to be much more effective than other rival organizations elsewhere.

The Cloud as it comes near the solar system should speed up due to the gravitational pull of the sun but something strange happens : it stops and settles down cosily between the earth and the sun. This cuts off the sunlight and as a result the life on the earth starts to wither away. Soon, however, the Cloud widely spreads out and the rays of the sun creep through to reach us. This curious 'misbehaviour' of the Cloud is analysed and leads to the inevitable conclusion that the Cloud is alive or has living beings in it and, as such, it can control the effects of the environment. The scientists are able to establish wireless communication with it. Then the earth scientists stumble upon an eerie knowledge. The Cloud is a highly organized form of life—civilized, benevolent and wise.

After some time, however, the Cloud pulls out to help another fellow-cloud in distress about two light-years away. (Let us see, what a student can learn from this novel.)

Exobiology

Exobiology, the science of life in outer space, is still in its infancy. "The eternal silence of the infinite space frightens me", wrote Blaise Pascal in his *Pensees*. We are now on the threshold of the time when this silence is going to be broken.

In 1960, the project Ozma of the U.S. National Radio Astronomy Observatory made a preliminary search for any signals originating from intelligent life elsewhere in or out of this solar system. But this proved abortive due to the lack of sufficiently sophisticated equipment. The scientists, however, learnt about coding and signalling procedure that we might need for announcing our presence to the rest of the universe and at the same time for decoding a sequence of dots-and-dashes flashed out by any extra-terrestrial intelligence. Any young student reading these lines may, let us hope, live to see a successful outcome of similar future trials.

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* First published by Willian Heinemann Ltd., 1957, Reprinted by Penguin Books, 1960, 1961, 1963, 1964, 1965, 1967, 1968, 1971

The question that we have to ask ourselves is regarding the kind of life that we may hope to encounter in the outer space. Life, as we know it, is based on carbon compounds, more specifically, proteins and nucleic acids. In their absence, life would not be possible.

Michael Creighton, in his otherwise extremely readable novel, *The Andromeda Strain*, another science fiction, conjures up the existence of bacteria not based on these compounds. One can safely say that such creatures are not possible except in fiction. Some scientists doubt whether a non-carbon biochemistry would at all be possible. Yet, alternative life forms cannot be entirely ruled out. For instance, the hydrides of boron are perfectly stable compounds, though they do not occur naturally. This is due to the fact that intermediates necessary for their formation are disrupted by oxygen and water. On a planet where these substances were not so ubiquitous, these boron hydrides could easily be formed and they might play an important part in a boron biochemistry. Whether any animate structure thereby evolved may be termed 'living' would then be a matter of nomenclature.

Fred Hoyle makes a much more far-reaching departure. The life-form Hoyle imagines consists of nebulous matter. One is tempted to say that it is life created in the image of a theoretical astronomer. Though justly ignored in Linnaeus' classification, a look at the Crab Nebula makes such a tongue-in-the-cheek hypothesis attractive. To be taken with more than a pinch of salt, the book achieves a suspension of disbelief from its beginning to end.

The density of Cloud is very low : a cube of this material with a hundred metre edge-length weighs only as much as a litre of water. Yet, it is so large that its mass is about two hundred times that of the earth. Its mode of operation is through inorganic material and electro-magnetic processes. Its neurological structure is arranged all through it in discrete parts and new material can be added to it as and when required. There are a number of similar clouds spread over the entire universe.

For maintaining order in its vast design, the Cloud needs energy—as all forms of life do. The life on earth is based on photo-synthesis or the tapping of the energy of sunlight by the plants. The Cloud, too, gets its energy from a star, though it cannot while away too long near a particular star, as the gravitational process would force it into becoming a satellite, and the resulting condensation would destroy its orderly animate structure.

The Cloud energizes itself by the light of a star and then fires away masses of matter (the rocket principle) in order to move away. Thus engaged in its endless odyssey it personifies Wordsworth's line : "I wonder lonely as a cloud".

It is devoid of sex and there is no reproduction as such. The propagation of the species is carried out in a different manner. When such clouds, in their wanderings, encounter any suitable nebulous matter, they re-arrange the parts in such a way that consciousness and vitality can emerge on their own from this 'seed'. Such 'baby clouds' are then left to fend for themselves and they gradually develop in interaction with their peripatetic environment. All this is reminiscent of genetic engineering : creating life in a test-tube through artificially synthesized eDNA:

Consider now the characteristics of life as we know it vis-a-vis the Cloud. Besides using protein and nucleic acids, life distinguishes itself by a capacity for reproduction and heredity, as also by adaptability to surroundings, mutability, spontaneous movement and irritability.

In a sense same of these aspects are contradictory. The purpose of reproduction and heredity is to produce similar organisms in order to perpetuate invariance in the species, whereas mutation is programmed to produce such changes as to make the organism more fit for survival. It is the interplay of such factors that makes life such a many-splendoured thing.

The Cloud is alive on all these counts. In some respects, the analogies are quite instructive.

Thus spoke Fred Hoyle's Cloud :

> "Your headaches arise from a faulty blood supply that destroys the precision of the electrical firing sequences in your brain. I experience something very akin to a headache if radio-active material gets into my nervous system...[producing] an extremely unpleasant subjective experience."

Though it cannot hear, the Cloud can appreciate music. For, after all, our appreciation of music has really nothing to do with sound... What we appreciate in the brain are electrical signals that we receive from the ears. Our use of sound is simply a convenient device for generating certain patterns of electrical activity. There is indeed a good deal of evidence that musical rhythms reflect the main electrical rhythms that occur in the brain. And don't you forget it.

The question of life is however more complicated than a package-plan of these and other qualities. Life, after all, is to be understood, by studying its origin and development. A robot is not alive even though we could probably build one endowed with all these characteristics. It remains a machine. When we apply this criterion on the Cloud, we find Hoyle slips up badly. We are told that there was no first cloud. It thus becomes an 'artifact' of nature, eternally alive in some mysterious way.

All the same, the Cloud is not a machine. As A. Szent-gyorgi has pointed out : machines deteriorate when used, whereas living systems decay if unused. The heart of a frog, for instance, can be made to stop for a minute or so. The first beat thereafter is very much weaken and the recovery is only gradual. The process of decay had already started and must be reversed.

As is well known, a machine can work more efficiently after a rest. But the order prevailing in the Cloud would be completely disrupted soon after an enforced stoppage. So there are all these pros and cons.

Get hold of the book and decide for yourself—even though Hoyle would not expect the analysis to be carried out to such a pedantic extent.

Now, something about the brain of the Cloud. Information transfer is possible through alternating currents and Hoyle bases the neurological functions of the Cloud on it. The A.C. generator required are feasible in the extensive cloud structures. The A.C. signal is accompanied by an electromagnetic radiation in space—the radio is based on this fact. The Cloud then broadcasts its thoughts as they are canceived and individuality between the separated parts of the Cloud is not possible, even though no nerves or wires connect one part of its brain with another. This is the essence of telepathy. But such an A.C. mode is physiologically not possible for animals (including the human species). Using such arguments, Hoyle can sweep away all the claims of telepathy as worthless. The emergence of telepathic Chrysalids in John Wyndham's science fiction of the same name is stripped off any scientific trappings. [His book *The Day of the Triffids* was discussed in the preceding issue.]

The neurological process in man are based on D.C. voltages. Any modulations in them are very small and are not accompanied by radiations. This voltage difference is brought about by the presence of potassium ions. K^+ and sodium ions Na^+ inside the nerve membrane and the fact that the membrane can allow sodium ions to enter it—if, creating a momentary local step voltage, called the action potential. The nerve impulse can then travel up to the spinal cord and to the brain by the firing of action potentials in contiguous regions somewhat similar to the ignition of a fuse—as a part burns up, it sets the adjacent part on fire and so on right down the line.

A better analogy is provided by a passive iron wire in the so-called Ostwald-Lillie nerve model. Iron is easily dissolved in dilute nitric acid. The reaction stops very soon in concentrated nitric acid. A fine oxide layer is first formed on the iron surface, and it prevents any further attack. If now, one end of the wire is scratched, the oxide layer is destroyed at this place and dissolution can take place. The oxide layer is re-formed, but during this process one finds that the neighbouring portion is disturbed and its layer gets stripped, when the acid starts to attack there. Thus an activation passivation cycle starts up and the dissolution and healing of the oxide layer travels step by step from one end of the wire to the other. This model lends itself to an easy demonstration in any laboratory.

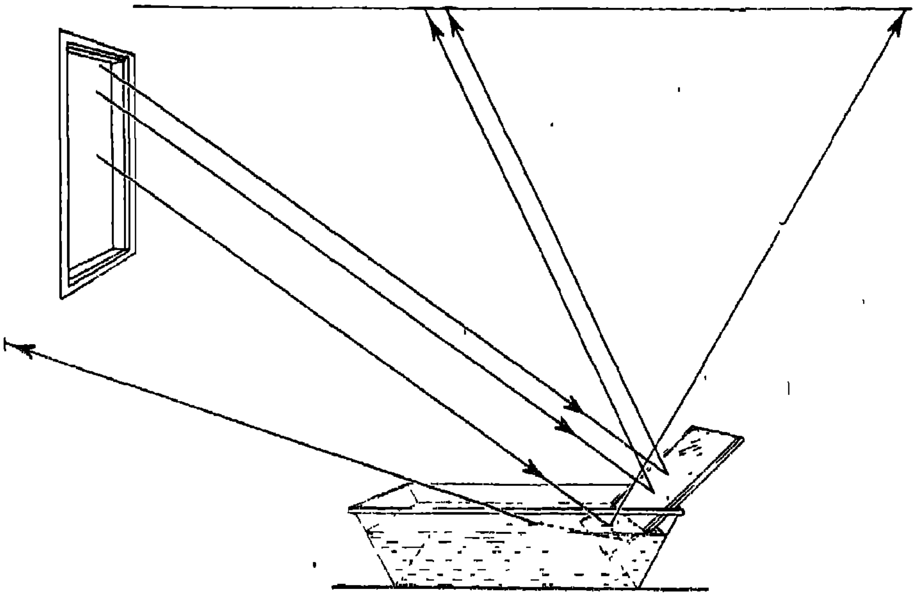
What, then, about the telepathic people—the so called mediums ? The procedure for the assessment of their claim is faulty. For, as Hoyle makes one of the characters of his book say, "It's no good doing a lot of experiments first and then discovering a lot of correlations afterwards, not unless the correlations can be used for making new predictions. Otherwise it's like betting on a race after it's been won."

Besides this, there is a dose of Astronomy, Physics, Communication-Engineering, etc.—put across in a far from dry-as-dust manner. There is also a discussion on the organization of science. Or how, for that matter, could it be predicted well in advance that the Cloud was coming in our direction ? One of the indications was given by the fact that the angular positions of the outer planets were not tallying with the calculated values. In fact, the planet Neptune was discovered in just this way. A discrepancy of this sort had been noticed for the planet Uranus. J.C. Adams in 1845 and independently U.J.J. Leverrier in 1846 calculated the position of a possible planet, which might cause this perturbation. They requested the observatories to verify this fact, saying in effect, in words of Professor Richard Feynman (see *Feynman Lectures on Physics*, Vol. 1), "Gentlemen, point your telescopes to such and such a place, and you will see a new planet". And, lo and behold, the planet Neptune was there, right on the dot, a slave to the dictates of Newton and his laws of motion. ☐

V.P. SHARMA
Lecturer in Chemistry
Kirori Mal College
University of Delhi

Students' Forum

A simple exercise to illustrate the processes of science: experimentation, observation, measurement, inference, etc. of the primary, middle as well as high school levels.



HOW TO STUDY THE COLOURS OF A RAINBOW ?

1. Take a thali/plate/trough and a plane mirror.
2. Select a place in your classroom where you get sunlight through the window.
3. Place the vessel (thali/plate/trough) in the way of sunlight and fill it with water.
4. Dip the mirror in water in and inclined position so that sunrays fall on it.
5. You will see a white spot (an illuminated area) and a coloured spot either on the wall or on the ceiling. You will get a third (white) spot also.
6. By changing the angle of inclination you can get the colour of the rainbow at a desired place.
7. Leave the arrangement as it is and allow the water to settle down.
8. Mark the white spot by means of a suitable piece of board or paper. You would see the colour bands more clearly.
9. Note down the colours that you can observe.

10. Note down the order of the colour bands in this 'rainbow' spot.
11. Try to measure the breadth of each colour band.
12. Note the direction of the sun rays falling on the mirror and the direction of the white spots as well as that of the colour spot.
13. Try to explain the observed phenomenon. Do you know what you have done ? Sir Issac Newton had demonstrated for the first time that sunlight (or white light) is composed of seven colours. He could separate them by using glass prism. He allowed a beam of sunlight to pass through the prism. The prism induces the beam of light to deviate and split it into its seven visible colours which can be seen on a screen or the wall behind the prism. ☐

V.K. SHINDHE
State Institute of Science Education
Poona

International Congress on the Improvement of Biology Education

Shri Suresh Chandra Jain, a science teacher in NCERT, represented the Council at the International Congress on the Improvement of Biology Education (Uppsala) Sweden and participated in the deliberations.

THE International Congress on the improvement of Biology Education was held at Uppsala, Sweden, from 8 to 12 September 1975. The congress was sponsored by Unesco and organized by the Commission for Biology Education of International Union of Biological Sciences with the following objectives :

(*i*) To identify and analyse the recent trends and problems of biology education;

(*ii*) to propose a four-year cooperative plan of action involving international, regional and national organization for further improvement of biology education, and

(*iii*) to prepare materials on various aspects of biology education. "New Trends in Biology Education" Vol. IV.

Eminent biology educationists prepared write-ups on topics based on the existing literature on the subject the following are the topics of the papers discussed at the Congress.

1. Trends in the purposes and objectives of biological education.
2. Preparation of biology courses to take account of new developments in biology and the needs of society.
3. The understanding of the learning process and the effectiveness of teaching methods in the classroom, laboratory and field.
4. The impact of new instructional equipment and educational technology in the process of teaching biology.
5. Trends in techniques and criteria used in assessing student achievement.
6. Recent experience and trends in designing and evaluating biology courses.
7. Trends in the biology component of education at primary and junior secondary levels.
8. Trends and problems in designing introductory university level biology courses.
9. Developments in the training and retraining of biology teachers.
10. Designing courses to meet the changing conditions and requirements for the professional use of biology in basic and applied sciences.
11. Role of the biology component in promoting the popular understanding of science.
12. Regional and international cooperation for the improvement of biology education.

An International Advisory Group in Biology was set up by Unesco with the consent of Commission for Biology Education. The group includes eight biology educationists from all parts of the world : R.A. Kille (U.K.), R. Hiller (France), Heinz-Werner Baer (GDR), I. Imahori (Japan), M. Lindauer (FDR), Saber Selim (Egypt) J.E. Kihlstrom (Sweden) and S.C. Jain (India).

The following specific proposals were suggested by the Congress and Advisory Group for the Unesco :

1. The programme to improve and reorientate biological education at junior (up to 14 years of age) level be set up at regional basis, showing that men and all his activities should be integrated with his natural and artificial environment, for his future survival and happiness. Programmes should not be descriptive but must include simple concepts, principals and ethics: Four steps were suggested to carry out the programme :

(*a*) workshops in curriculum development and the production of teacher's guides and teaching materials;

(*b*) study groups for teacher-training and re-training for the new curricula;

(*c*) development of programmes for community involvement, and

(*d*) dissemination of the recommendations and production of the programme at various levels.

2. Development of teaching materials on the effective use of the living and their conservation.

3. Biology courses for the non-biologists at college and university levels.

4. Training and re-training of teachers at various levels, especially those of the teacher-training colleges.

5. Dissemination of ideas and information.

6. Preparation of up-to-date, annotated bibliography of the work done in the field of biology education.

The Congress and the Advisory Group requested Unesco to implement these recommendations with a view to improving biology education at regional, national, governmental and non-governmental levels. ☐

SURESH CHANDRA JAIN

Science News

MAN FIGHTS DISEASES

India finds anti-leprosy drug

THE NEW long-acting injection for leprosy developed by the Haffkine Institute, Bombay, has been yielding good results. This injection has been successfully tried on leprosy patients in various leprosy centres in India. The injection would not cost more than Rs. 20 a year for a patient. The other areas in which the scientists at the institute are doing research are jaundice, cholera, tetanus and fungal diseases. The drug for jaundice is expected to reach the market in three years.

Indian scientists find a cholera-cure

THE CHOLERA Research Centre of the Indian Council of Medical Research claims to have made a breakthrough in the treatment of cholera and gastro-enteritis by developing oral fluid *therapy*.

Asia free of small pox

ASIA IS free of small pox for the first time in recorded history, the World Health Organization (WHO) announced. The last person to contact the disease was a two-year-old girl, Sokina Begum, in Bangladesh. Bangladesh was the last Asian country in which the disease was officially declared eliminated. Just six months ago there were still 3,900 cases there. The only country in the world still to have registered smallpox cases, WHO said, was Ethiopia.

Use of satellite in heart treatment

THROUGH the satellite Aryabhata, heart signals (ECG) were transmitted instantaneously from Sriharikota in Andhra Pradesh to Bangalore. The experiment on ECG transmission will be of immense help in providing medical relief to remote villages.

Breakthrough in heart transplant

DR. CHRISTIAAN BARNARD, the heart transplant pioneer, says a breakthrough in countering physical rejection of implanted hearts is "just around the corner". The hope is great that we will beat rejection in heart surgery and we are currently studying two known occurrences when the human body readily accepts a foreign body", he said. "These are the acceptance of a mother's body of her child forming inside her and the growth of cancer in the body. Both are foreign, out of alien tissue, yet they are accepted by the body." Once the problem of rejection is overcome, it will improve the efficiency of heart transplant operations. He noted that there had been about 270 heart transplants in the world to date but only 50 recipients had survived, including two of his patients. The use of a living animal (human) heart was superior to an artificial heart, which cost $ 70,000 and had not been perfected.

Definition of Death. "We prefer to take a heart from a dead person because a person can be dead while his heart is still beating as death only occurs by definition once the brain is dead. The body dies by degrees, with the brain dying after three minutes, the heart after three to four hours and the kidneys after 10 to 12 hours". Dr. Barnard said that in one case his team kept a heart beating for 36 hours inside a corpse while waiting for family permission to remove it. He said the practice of implanting a second heart pioneered by him last year was the best method in human heart transplants. "In most cases, the old heart still works, it just cannot cope", he said. "So we supply a second heart to help it out a bit."

New hope for the blind

SOVIET OPTHALMOLOGIST Svyatoslav Fyodorov has invented new artificial lenses by which sight has been restored to thousands of blind people. Fyodorov's unique artificial lens required only one-stage operation. It has won him patents in many countries, including the USA, where it is now in use. The lenses are called "Sputniks" because they look like the world's first artificial satellite. It took Fyodorov nearly 20 years to develop this plastic lens to replace that vital transparent part of the human eye. He makes the blind see again not only with artificial lenses but also with plastic corneas. So far he has restored sight to more than 2,000 people and his devices are gaining world fame as the latest in restoring vision to cataract patients.

Anti-cancer drug from Japan

A NEW anti-cancer drug, which can be taken orally and is free from all side effects, has been developed in Japan. The medicine is made from extracts from a species of mushroom called Kawaratake which grows chiefly on Red Broadreef tree trunks. The medicine is good for cancer of the stomach, the lungs and various other organs.

Anti-leukemia vaccine

AN AMERICAN-GERMAN team of scientists has reported to an International Leukemia Conference the first ever successful cure and prevention of virus-triggered leukemia in mammals with the use of purified viral antigen and antiserum. If, as mounting evidence indicates, human cancers are in fact triggered by viruses the method could open the door not only to the leukemia patients, but also to vaccination against the disease. The achievement was reached in close cooperation between a team led by Dr. Werner Schaefer of Max Planck Institute for virus research, Tuebingen(West Germany), and Dr. D.P. Bolognes of Duke University Medical Centre, Durham (North Carolina). The American-German cooperation led to the isolation of a sugar protein from the surface of virus causing leukemia in mice. The protein molecule proved effective in preventing leukemia in mice—that is vaccinating them—and also in producing an antiserum halting the disease in the already infected mice.

Cure for bleeding ulcer

AMERICAN DOCTORS have identified a hormone which they say will prove a "sure safe" cure for bleeding ulcers. A team of research workers at the Memorial Sloan-Kettering Cancer Centre and Cornell University Medical College report that an injection of a growth hormone—somatotropin—into the patient's muscle completely stops bleeding within 24 hours. The injections are continued once a day. Within three to five days a tissue forms over the ulcer and it becomes just another wound that is going through the normal healing process. Bleeding ulcers are known to be the hardest to treat and are often fatal.

DISCOVERIES & INVENTIONS

Indian scientist prepares superbug

AN INDIAN scientist, Dr. Ananda Chakrabarty (37), has bred a 'superbug' that could clear oil spills on rivers, lakes and the high seas like a vacuum cleaner if it performs as well outdoors as it does in the laboratory. He has developed a hybrid, combining four different strains of petroleum-eating bacteria, that chews up oil at a rate several times faster than any other known organism. This microbe promises to be only the first in a growing family of sueful man-made organisms that could be created by his genetic engineering process. Other micro-organisms could be tailor-made to convert petroleum into protein for animal food and perhaps even food for human beings to enhance the flow of petroleum from aging oil fields, and even to concentrate gold, uranium, platinum and other valuable metals from various ores. Dr. Chakrabarty's super microbe is still in the laboratory state.

Indian scientist discovers new particle

AN INDIAN scientist, Dr. Pyare Lal Jain, working in the USA has discovered a nuclear particle named "charmed particle". The existence of this key-particle was predicted six years ago to explain the mysteries of high energy physics. Scientists working with atom smashers all over the world had been searching for it. The discovery of the particle will have a great impact on physics as a whole. The new particle was created by shooting protons of 300 billion volts energy on a target. The protons were produced by the fermi accelerator, world's biggest atom smasher near Chicago. The charmed particle is about one-and-half times and heavy as a hydrogen atom and lives for an extremely short, time ranging from one trillionth to one-tenth of a trillionth of a second. After that it breaks into three known particles. Because of its short life it travels only 194 'microns' or less than one-fifth of a millimetre. One micron is one-thousandth of a millimetre. It was theorized 15 years ago that all particles in the nuclear "zoo" are made up of three kinds of fundamental particles called "quarks". The need for a fourth quark (charmed quark) was realized six years ago and its existence was predicted but like all other quarks, the charmed quark remained undetected.

Oil from plant Alternative fuel

TWO AUSTRALIAN scientists, searching for alternative energy sources, are studying a green slime which produces crude oil.

The slime, *Botryococcus* grows on inland lakes and dams where it is blown to the shores, dies and dries into a black substance resembling old shoe leather. The plant, a green algae, stores energy from the sun as hydrocarbon, not starch or carbohydrates like most plants. It produces a hydrocarbon oil, unlike most plants, which produce an alcohol.

About 100 years ago, European discoverers and settlers thought it was solidified oil and shipped 10 tons of it to England, where it was turned into crude oil.

Hydrocarbon fuels have been found to be the most efficient fuels for vehicles and especially aircraft.

Microscope magnifies 10-million-fold

AN ELECTRON microscope, developed by a West German firm, is capable of indicating two lines separated only by a single atom. The power of magnification is 10-million-fold. A match-stick magnified to this extent would be 400 km across. The new microscope can be used not only for all known varieties of electron microscopy but also for extreme precision in chemical analysis, quantifying substances in amounts of as little as a thousand millionth of a gramme.

MAN & COSMOS

Man studies venus

THE SOVIET interplanetary automatic station Venus-9 went into orbit round the planet

Venus to become the first artificial satellite of the planet in history. Simultaneously, the descent vehicle of the station softlanded on the surface of Venus. Fifteen minutes after its touchdown, the first photographs of the Venusian landscape were received. The Venus probe, which had covered the distance of more than 300 million km in 136 days, was put on "an elliptical orbit of an artificial satellite of Venus with the minimum distance from the planet's surface of about 1,500 km and the period of revolution of about two days".

The probe code-named Venus-10, also relayed measurements of sunlight levels at the surface and information about the Venusian soil. Venus-9 surprised Soviet scientists by revealing a landscape strewn with stones instead of the wind-swept desert many had expected. While the descent vehicles of both Venus-9 and Venus-10 have been killed by the intense heat, the orbital modules—the first man-made objects ever to circle Venus—are continuing to send back observations of their own on the planet and surrounding space. The Venus-10 lander reported a temperature of 465 degrees centigrade—and a pressure of 92 atmospheres. It also recorded a wind speed of 3.5 metre per second. The fresh data should give a clue to the history of the planet. One Soviet geologist, Dr. Alexander Badnevsky, has already said that the sharp, young appearance of the rocks testifies to a comparatively recent volcanic eruption or groundswell and the planet could still be "alive" inside.

MAN & ENVIRONMENT

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500 crore rats to go

A FIVE-YEAR national plan for rodent control has been evolved by the Indian Council of Agricultural Research. Students and staff of universities, the ICAR, voluntary organizations and Central and State departments will be involved in implementing the plan. According to the ICAR, there may be about 2,400 million to 5,000 million rodents in the fields, in addition to 1,000 million rats in residential areas. Students and volunteers would collect dead bandicoots, skin them, treat the skin with chemicals and forward it to the Central Leather Research Institute in Madras for "by-product utilization". The programme is aimed at controlling the number of rats. Complete eradication of rodents "may create an ecological imbalance". Implementation of the plan is expected to begin shortly.

Pest control and afforestation

THE NATIONAL programme includes pest management, weed control and planting and saving of trees. It involves control of "white grub", a pest that causes 40 to 80 per cent loss to crops in Maharashtra, Gujarat, Karnataka, Rajasthan, Tamil Nadu and Orissa and spreading to other States. The weed control plan will be taken up on a "massive national scale". Planting of suitable types of trees on community land, canal bunds, railway lines and in the rural and urban areas will be taken up.

ASTROPHYSICS

'Big bang' of creation

ASTRONOMERS recently picked up microwave signals froms pace that date back to the beginning of time that created the universe 10,000 million years ago. Sir Bernard Lovell, Director of the Jodrell Bank Radio Telescope Station, U.K., said. He said the signals were first picked up accidentally on equipment testing space communications several years ago and later were monitored by equipment abroad a rocket shot above the atmosphere. The signals, he said, were radiated when the 'material' that became the universe was concentrated in a single primeval fireball, ready to explode into pieces that would become stars and galaxies. "Apparently we observe today a radiation which is a relic of the high temperature phase of the universe", Sir Lovell commented, "perhaps within a second or so of the beginning of the expansion." He said that the creation hinged on the force of attraction between two protons, positively changed subatomic particles whose nature was determined a million of a second after the 'big bang' occurred in temperatures that reached 10 million degree. One second after the cataclysmic explosion came the "critical period" when the levels of hydrogen and helium were determined in the universe—and the shape of space and life, as we know it, formed.

From this original explosion, it is claimed, primeval matter of almost inconceivable concentration and density, spread out into the present galaxies according to the second law of thermodynamics. The theory of the expanding universe might seem to argue an original concentration, but not everyone accepts that either. Some astronomers think that it expands in some sectors and contracts in others, some that it pulsates.

Riddle of the quasars

QUASARS, known since the late 1950s as the farthest object man has found in the universe and thought to have been small galaxies billions of light years from earth, might not exist. The term 'quasars' is an abbreviation of quasi-steller, meaning 'star-like'.

That is the theory being explored by three Australian scientists at the physics department of Monash University, Melbourne.

Their hypothesis is that the quasars are formed spontaneously by oscillations set up by the electro-magnetic fields around nearby stars. They are not, as thought previously, star-like bodies themselves.

When several stars move into certain positions, oscillations set up in their electromagnetic fields might be locked in until they burst out as intense energy sources of light and radio waves at a rate of about 100,000 billion times as fast as the sun's rays.

Solar system's original 'material'

A RARE meteorite has recently been located in Western Australia. The 'carbonaceous chondrite type 2', as the meteorite is known scientifically, is the last remnant of the pristine matter, according to Dr. John de-Laeter, Dean of Applied Science, Western Australian Institutes of Technology. He said that by examining carbonaceous chondrites scientists could get a better understanding of how the solar system and the stars originated.

GEOLOGY

India moving north-east

ASIA HAS BEEN formed by collisions of at least three small continents and the pressure of one of them, the Indian subcontinent, still continues to twist the Asian landscape. This is the conclusion of the Chinese geologists who recently scaled Mount Everest—they call it Mount Jolmo Lungma—and some American scientists taking an overview of Asia from spacecraft. A delegation from China described the recent findings at the colloquium at the Geological Observatory of the Columbia University.

The successive collisions have produced the largest continent, the highest mountains and the loftiest plateau on this planet. They say that Asia's complex pattern of earthquake activity is now seen as a manifestation of crustal movements on a grand scale. India's northward drive is pushing sections of the earth's crust in various directions. While early proponents of the theory of 'continental drift' believed that the Tibetan plateau rose 2.5 miles above sea level when a great slab of the Indian continent pushed more than 1,200 miles under Asia.

Asia, until hit by India, was moving north-east at four-tenths to seven-tenths of an inch yearly. It then slowed down to two-tenths of an inch a year and the movement continues.

Prof. Brian Chadwick, who recently visited

India, said that the Australian continent is still moving towards Asia and when the two continents collide there will be a mountain range in Indonesia as large as the Himalayas. Fortunately, this is not going to happen for several million years. Prof. Chadwick, who teaches geology at Exeter University, has done research in the Western Alps and in East Greenland.

HONOURS & RECOGNITION

Nobel prize winners in physics and chemistry

An Australian and a Swiss national have shared the Nobel Prize in chemistry for simplifying the production of biological substances like medicine, while two Danes and an American received the physics prize for their contributions to nuclear physics. Dr. John Warcup Cornforth, 58, an Australian living in England, and Dr. Vladimir Prelog, 69, a native of Yugoslavia, now a Swiss citizen, shared the chemistry prize for "work on the stereo-chemistry of enzyme-catalyzed reactions and research into the stereochemistry of organic molecules and reactions".

The Swedish Academy of Sciences announced that Professor Aage Bohr and Professor Ben Mottelson (Denmark) and Dr. James Rainwater (USA) had won the physics prize for their research and contribution in nuclear physics, specifically for their findings regarding the nucleus.

Dr. Cornforth is a professor at the Milsted Laboratory of Chemical Enzymology, in Sittingbourne, Kent (U.K.), while Dr. Prelog is a professor at the Eidgenoessische Technical College, Zurich.

The Academy spokesman, Professor Holger Erdman, said Dr. Cornforth mapped out the formation of cholesterols which contained "the key to sex, hormones". The tax-free chemistry prize, valued at 630,000 kroner (£69,000) will be shared by Dr. Cornforth and Dr. Prelog. The physics prize, also worth 630,000 kroner, will be divided between the three winners. The importance of the work of Prof. Bohr, Prof. Mottelson and Dr. Rainwater is that it tells more about the fundamental forces locked in an atom. Prof. Bohr is the son of Niels Bohr, winner of the 1922 Nobel physics prize. Dr. Rainwater developed the theory that the atomic nucleus is not always spherical but can also be egg-shaped.

LONG LONG AGO

Apes that lived 2 crore years ago

A rich collection of primate fossils, 15-20 million years old, has recently been discovered in the Sivalik range in Himachal Pradesh. The discovery was made by a team led by Dr. S.R.K. Chopra, Head of the Department of Anthropology, Panjab University.

This extinct species is called *Indra Loris*. This gibbon-like primate was found in the Nagribeds comparable to the Middle Miocene geological stratum formed 15 to 20 million years ago.

Indra loris is essentially more similar to gibbons than to any other apes. It shows characteristics which are considered prominent features seen in the evolution of homonoids (man-like apes) and hylobatids (gibbons).

In this connection it may be noted that the remains of the earliest known hylobatids have so far been found in the Miocene deposits of East Africa and Europe.

Animal worlds 40.5 lakh years ago

Twenty completely new species of marsupial have been found in a fossil deposit in the north-east of Australia. (A marsupial is a pouched mammal like Kangaroo).

The fossils, which include the remains of a marsupial lion and a hippopotamus-sized wombat, are extremely well preserved. They are at least 4,500,000 years old.

The deposit has been excavated by a team from the Queensland Museum, Brisbane, led by Dr. Michael Archer, the Museum's curator of mammals.

Other fossil animals found include a new type of bandicoot, an extinct type of crocodile, a number of hippopotamus-like creatures, an ancestor of the modern koala, a giant snake, a number of new types of Kangaroos, birds and some small lizards and rodents.

Camel : first domesticated animal

Excavations made by Leningrad archaeologists in Turkmenia have settled the long-standing dispute of historians as to which of the steppe draught-animals was first domesticated by man. The answer is camel. Its bones were discovered in soil layers of the third millennium B.C. No traces of domesticated horses or donkeys have been found. ☐

Have You Read These Books ?

THE COMMONSENSE OF SCIENCE

J. Bronowski, Pelican Books, 1960, Penguin Books Ltd., Harmonds Worth, Middlesex, U.K., first published by Heineneaun, 1951. (Cheap and available in Indian market)

FIRST PUBLISHED way back in 1951, J. Bronowski's book has been waging a war, and steadily winning it, against the dichotomy between art and science.

We have long been suffering from a delusion that some periods in the history of civilizations are remarkable only for their artistic creativity : 'golden ages of art'. And a logical corollary of this delusion is that the current period the age of science and technology that started with the Industrial Revolution in the eighteenth century—is deficient in humanistic sensibilities and artistic creativity.

But, "much of this quarrel between science and soul", Bronowski rightly points out, "was, trumped up by the religious apologists of Queen Victoria's day, who were anxious to find science materialistic and unspiritual...It was made by the timid and laboured artists of the nineties in order that they might by comparison appear to be creative and intuitive."

Evidently, this view of contrariness between science and art intends to deny creativity to scientists. And this delusion is also associated with sundry other views like 'science destroys culture' and that 'the arts flourish only where the sciences have been neglected'.

These are directly contrary to history. We should look back into our past to fight this delusion of a dichotomy between science and art. Because the best approach for a layman to understand the progress of science and technology is historical.

Let us listen to Bronowski again. He lays bare this dichotomy as unhistorical : "what is this golden age of art untarnished by the breath of rude mechanics ? Where did it exist ? In the East ? The civilizations of Egypt, of India, and of Arabs belie it. The only oriental poet at all well known in England, Omar Khayyam, was a Persian astronomer. In the West ? The culture of the West begins in Greece; and in the great age of Greece, art and science penetrate one another more closely than in any modern age. Pythagoras lived before Aeschylus had created Greek drama. Socrates taught when that drama was at its greatest......"

This is historically correct. The art-science dichotomy is historically wrong. Let us have a view of more recent times. The Elizabethan age, for instance, was the golden age of literature. But it was also an age of expanding horizon in geographical and astronomical knowledge and commercial and industrial activity. And it was not an accident that Sir Walter Raleigh's (the voyager) own circle was dominated by a mathematician and astronomer Thomas Hariot. It was not an accident either that the first table of logarithms was published within a few years of Shakespear's First Folio.

Bronowski then presents another irrefutable historical fact : the first meeting of the Royal Society, held in November 1660, was addressed by Christopher Wren the architect. He spoke on astronomy. Besides, "when the society wanted to encourage the use of simple and lucid prose, it appointed a committee" which included John Dryden, the poet.

As for the 'dehumanizing' influence of science and technology, how could we forget that the age of Industrial Revolution is also the age of Romantic Revival, and that the poets William Blake and Coleridge were contemporaries of Arkwright and James Watt ?

Let us read the book to have a commonsense view of science. Specialization will come only with work. The basic unity and interconnectedness of all the disciplines has to be grasped if we want to narrow down fruitfully to an area of specialization.

THE TWO CULTURES : A SECOND LOOK

C.P. Snow, Cambridge University Press, 1965

C.P. SNOW, a scientist by training, is an illustrious writer in English language. His novels are acclaimed for their deep insight and excelling literary qualities.

Because of his training as a scientist and his success as a writer, C.P. Snow is known and respected both in scientific and literary circles: He has noted that the men of science are usually unaware of what is happening in the world of art and literature. And the literary artists, on the other hand, seem to have grown a kind of contempt for anything scientific or technological, and are usually ignorant of the changing world of science and technology.

This lack of communication between the two groups of talented men and women has so far deprived either side of a fruitful totality of human experience and endeavour. And this division or the emergence of 'two cultures' (one scientific and the other literary) has distorted man's planning for the future.

The first part of the book is his Rede Lecture that C.P. Snow delivered at Cambridge in 1959. In his lecture Snow analysed the mutual incomprehension that in separating the two cultures and elaborated on the ill-effects of this division (we discussed this point in our Editorial of the previous issue of *School Science*).

His Rede Lectures on two cultures caused so much bitter controversy that C.P. Snow had to write *The Two Cultures : A Second Look* which forms the last half of this book. In this part the author discusses the points he made in his Rede Lectures.

It is a thin volume of less than hundred pages, and while going through the book the reader will not fail to see the social implications of science and technology and the necessity of evolving an educational system which balances both 'science for all' and 'arts for all' on the same broad base of mass education. □

—SANTO DUTTA

Book Review

THE EDUCATIONAL USE OF LIVING ORGANISMS : A SOURCE BOOK

P.J. Kelly & J.D. Wray, The English Universities Press Ltd., 1975 (Agents in India : P.I. Publications, Bombay, Calcutta, Delhi)

EVER SINCE its beginning as the science of life, biology had been suffering, till recently, from a strange paradox. Classroom teaching of the subject has so far been restricted to dissecting dead animals or faded flowers, or to observing a still lifeless, stuffed or fixed organisms. May be, for a change, there would be visits to the Zoos, more with a picnic spirit than with a desire for knowledge.

But, as it is with the living world itself, the method of teaching and the infrastructure of curricula are also gradually changing. The student of biology is being exposed more and more to the living world. Gradually, we are taking our students out to investigate the living organisms, their diversity, their variation, their interrelationships and their life processes. But we are badly in need of suitable instructional materials for the students or more so for the teachers.

Here is a source book on the educational use of the living organism. In fact, we had been waiting for this kind of source book. Reading between the lines, one would not miss two essentially unique features which characterize this volume. One is the practical approach to the problem. This pertains to the choice of particular biological organisms and to the feasibility of a steady flow of supply of those organisms to the schools and colleges. The authors have dealt with these aspects from a practical viewpoint. The other feature, seldom emphasized and rarely realized, is the philosophical aspect of the problem. A living animal is a part of nature, a part of the ecological web of life. It is a complex and dynamic life-form, viewed here as something far beyond a physically or chemically analysable entity.

The main bulk of the book, however, deals with the supply and choice of suitable organisms for educational use. The series of articles in Section I gives numerous variations of the live materials in different countries. This, I believe, would give us useful information when we choose living organisms in different parts of the country, depending on the availability of the local flora and fauna. The article on the problems of introducing new biology in Africa would give us additional information on how to organize outdoor laboratories and on the opportunities for *in situ* studies with the limited resources available in a developing country. The next article discusses in practical details the technical knowhow of establishing a secondary school garden and how such a natural laboratory could be used to study genetics, biology, rural studies, and last but not the least, team teaching. E.V. Wray, one of the editors of the present volume, has discussed in minute details the possibilities of using nature trails as a teaching aid. The organisms would vary and details differ, but similar attempts should be made in our country. It would certainly pay us rich dividends. The same thing can be said about the use of parks in secondary school biology programmes. The reader will find enough food for thought in the article by F.A. Gornall on the use of parks in secondary school biology programmes.

I.B. May's article on man as an animal for investigation would prove fruitful in many a way. There is a greater need today, than ever, to understand man as a child of nature.

Section 2 deals with handling of biological specimens : the code of practice, safety measures to be taken while using live organisms and the problem of infections carried by them.

A ready supply of live organisms or selected seeds is a formidable problem in any country. Each country or each part of a country will have to solve the problem in its own way. Section 3 gives a picture of how the schools in Great Britain handle this problem.

Section 4 gives a useful catalogue of organisms, their suitability for teching a particular topic and some additional notes. This would prove indispensable to any biology teacher. It offers a very wide choice for the teacher and the taught in any part of the globe.

The penultimate chapter enlists the sources of information on materials and organisms. The reader need not be disappointed with the list as it is meant for users in the Western countries. Why can we not make available the same kind of information relevant to our school conditions and even to our research laboratories ? That will be a useful compilation.

Any reader, whether a teacher or a student, would find in this volume a down to earth experience of the use of living organisms in schools. It would be equally rewarding to those who frame biology curriculum for our schools.

A word or two more.

This is a resource material developed on the basis of Educational Use of Living Organisms, (EULO) Project of the U.K. One would look forward to seeing such projects taken up in our country. Our resources may prove to be greater. ☐

UTPAL MALLIK

Science Exhibition for Children—1975

A REPORT

ARUN K. MISHRA

Associate Organising Officer
NSE '75, New Delhi

THE FIRST NATIONAL SCIENCE EXHIBITION FOR CHILDREN was held at the National Physical Laboratory, New Delhi, in the year 1971. Since then such exhibitions have been held every year at Teen Murti Bhavan as a part of the nationwide celebrations of birthday of the late Prime Minister Jawaharlal Nehru, through the joint collaboration of the Nehru Memorial Fund and the National Council of Educational Research and Training.

Prime Minister Nehru had profound faith in science as an integral element for national development and visioned children as the future builders of the society.

In the contemporary society science is not only the concern of the specialists only but of everyone. In a message to children of the National Science Exhibition 1975, Prime Minister Indira Gandhi said : "No one can live intelligently in the world of today without understanding the facts and forces of science. In the days to come science will have an even greater impact on our daily lives. It is important for children to extend their familiarity with various branches of science. Everyone should have a basic grasp even though only a few will become specialists."

In the new 10+2 pattern of education science has been made a compulsory subject from classes I to X. If everyone must study science then the subject-matter and methodology have to be made interesting and attractive.

The major problems in science education today are : How can science and mathematics education be made an exciting and creative experience for the students and teachers? How scientific information expanding at such a terrific pace and becoming more and more abstract, can be popularised and how can the spirit of science communicated to the people ? How can scientific knowledge be made functional and relevant to our present and future socio-economic problems ?

One of the ways in which these problems are being approached is through science exhibitions being organised at national, state and district levels. Science clubs and science exhibitions are places where future scientists and technologists are being nurtured. The main objective of these clubs and exhibitions is to cultivate interest in science to create awareness towards social obligations of science and enthuse creativity leading to the solutions of man's problems.

With these objectives in mind the National Council of Educational Research and Training in collaboration with the Nehru Memorial Fund and various state governments organized 10 state level and 18 district level exhibitions throughout the country, in addition to the National Science Exhibition at New Delhi. These efforts were praised by President Fakhruddin Ali Ahmad during inauguration of the exhibition on 11th Nov. 1975 in these words: "Such exhibitions have vital roles to play in infusing scientific interest and skill in our young people. A science exhibition, such as this one, provides singularly unique opportunity to pool together the ideas and experiences about the present-day problems of our society, of the nation and of the race we belong to."

"Let the science exhibitions, like the one we are going to open in a few minutes, spread ...all over the country....convey the message of science to the remotest village. Let such happy excursions from classrooms be a forum for free interplay of ideas that originate in the minds of the children."

In the following pages an attempt has been made to present an evaluative account of the National Science Exhibition for Children 1975. Other district and state level exhibitions have also been described. The approach in this report is to discuss present experiences, the expectations and responses of the participants as guidelines to the organization of such events in future.

Selection of Exhibit-Areas

For the selection of areas recent national and international developments and timely topics were kept in mind. Conventional subject areas like physics, chemistry, biology etc. were avoided and attempts were made to keep these exhibit areas in conformity with present socio-economic problems and human endeavours. In the light of the growing awareness of threats to our environment, pollution and depletion of our natural resources and national and international efforts for environmental improvement, "Human Ecology" was conceived as the main theme for this year's exhibition. 'Women and Science' was thought of in the spirit of the current International Women's Year. "Space Science" bore relation to our recent national achievements in this area though "Aryabhata" and "Communication and Transport" was to particularly highlight the breakthrough in national communications through the SITE programme "Energy and Fuels" was relevant to the growing concern about energy-crisis and our successes in oil explorations at the Bombay High. Two other areas were "population and Food" and "Nutrition" with the intended theme of feeding the millions, "Human disease" "Science in the service of man", "Automation", "Scientific Games and Pastimes", and "Innovations in Teaching" were a few others.

Participation of Public Sector Laboratories and Research Institutes

It has been customary to invite public sector science laboratories to set up their pavilions in the National Science Exhibition. Bhabha Atomic Research Centre, Trombay, India Institute of Petroleum, Dehradun, National Chemical Laboratory, Poona, Central Health Education Bureau, New Delhi, Central Electronics and Engineering Research Institute, Pilani, Ministry of Agriculture, Extension Division, New Delhi were among those who participated this year. In addition, the creative Teaching Unit of the Department of Physics, Aligarh Muslim University also displayed their new ideas in the form of teaching models.

The idea behind the participation of public sector undertakings in the science exhibition for children is to make the school students aware of the national scientific forefronts in various branches of science and technology. Students thus get a direct vision of the relevance of science in solving the day to day problems of man and the society.

In the present practice the NCERT, as a rule, does not provide any financial assistance towards their participation. This may possibily be one of the reasons for poor initiative and enthusiasm of many of the institutions which failed to participate despite our request. It is suggested that in light of the great utility of these institutions in such exhibitions for children a more effective method of persuation and planning should be followed. The idea of sending letters of invitation to a large number of institutions may be abandoned. Alternatively, 6 to 12 such institutions may be selected for each year's exhibition and persuaded to display their achievements in the NSE. The financial aspects should also be sorted out and financial assistance provided if the participating Institution is not in a position to afford a part of whole of the expenses. Such an assistance may be more desirable to attract some of the science departments of country's famous universities.

Other Educational Bodies

The Kendriya Vidyalaya Sangathan, Municipal Corporation of Delhi, New Delhi Municipal Committee and the Work Experience Unit of the Delhi Education Directorate were provided with separate stalls for their exhibits. These institutions were themselves responsible for the selection and display of their articles and the management of their respective stalls.

Participation of Foreign and International Agencies

The participation of a large number of foreign countries and UN agencies like Unesco and UNDP was invited. The response to our invitation was overwhelming though the actual participation in terms of the number of exhibits was not as marked as it could be. Some of the sources expressed inability to participate this year (nevertheless assuring participation for the next year).

For this year's exhibition exhibits and films were received from U.S.A., U.S.S.R., U.K., G.D.R., Nepal, Malayasia, Belgium, Denmark, UNDP and UNESCO.

Layout

The pavilions were located in the south-western periphery of the lawns of Teen Murti Bhavan. The exhibit areas were located in a row of 12 pavilions followed by 2 pavilions of Kendriya Vidyalaya Sangathan. The stalls of foreign countries, NCERT, other educational agencies and public sector laboratories were located in a semicircle in the garden beyond the lawns facing the rear of the Bhavan. For the easy flow of visitors unidirectional arrangement of stalls was followed. The stalls being on only one side the side facing the stall having green foliage all around provided space for open air display of exhibits requiring such situations. It also provided space for proper erection of boards with important quotations, and other placards to go with the theme of the respective exhibit areas.

This arrangement of pavilions is not the best that one could visualize. While offering scenic frontage, and ample open space it suffered from the drawback that the crowding was severe in the first 15 pavilions nearer to the entrance gate while those pavilions in the semicircular area remained relatively neglected. Also the continuity of the theme areas got obscured in the public sector areas. It may be a better arrangement to have the theme areas on one side and related public sector pavilion on the facing side. This will considerably diffuse the visitors and place the public sector laboratories in related theme areas so that children's models and national achievements are displayed facing each other. The children would thus get a better idea of the horizons of science and its relevance to society.

Inaugural Function

The NSE '75 was inaugurated at 11 a.m. on the 11th November 1975 by President Fakhruddin Ali Ahmad. The welcome address was delivered by the Honourable Minister of Education Shri Nurul Hassan and vote of thanks was presented by Dr. Karan Singh, President, Jawahar Lal Nehru Memorial Fund. Prime Minister Smt. Indira Gandhi was also present during inauguration and spent over an hour visiting different stalls and talking to the children.

Cultural Evening and Popular Scientific Lectures

Two eminent scientists delivered popular scientific lectures during the course of exhibition. Dr. A.P. Mitra of the National Physical Laboratory gave a talk on "Threat to ozone environment of the atmosphere" and Prof. M.R.N. Prasad of Zoology Department, Delhi University, spoke on "The relevance of basic sciences to medicine and agriculture." These lectures created a great deal of interest among the young science student as evident from the questions and discussion that followed each lecture.

An attractive cultural show of variety entertainment was also put up by the local as well as the outside participants at NIE Campus. Regular daily film shows continued throughout the entire duration of the exhibition. Educational films were shown at the exhibition ground and feature films in the evening at the NIE Campus.

A visit to 'Son et Lumiere' show, "Tryst with Destiny" at Teen Murti House was also arranged for the participants.

Statistics

The exhibition at Teen Murti Bhavan remained open to visitors for 10 days. The exhibition hours were generally between 10 a.m. to 4.30 p.m. An estimate of daily visitors was placed at 25,000 to 30,000 on an average.

About 500 students and teachers from different parts of the country participated in the exhibition and about 450 exhibits were put up and demonstrated by them. The participating schools numbered about 300 in all. Rural and urban areas were nearly equally represented. A total of 791 certificates were awarded which included such students and teachers also who worked on the preparation of exhibits which were displayed but were not invited to accompany their respective exhibits.

Network of Science Exhibition

In addition to the National Science Exhibition at New Delhi the JNMF and the NCERT sponsored 18 district level exhibitions in 15 states and 10 state level exhibitions in different states under the joint collaboration of the respective state governments. The state level exhibitions were held at Jawahar Bal Bhavans at Trivandrum, Bangalore, Pondichery, Swaraj Bhavan at Allahabad and at different schools, community science centres etc. at Madras, Bombay, Ahmedabad and Banswara (Rajasthan). The state level exhibitions in Andhra Pradesh, Karnataka, and West Bengal are yet to be held. The district level exhibitions were held at Salumbur (Rajasthan), and all our district headquarters of Sikkim, Trichur (Kerala), Mandla (M.P.), Watrap (T.N.), Keonjhar (Orissa) and Raipura (Punjab). Some of the states could not hold their district level exhibitions during the month of November and would have them at a time more suitable to them. These were Bihar, Tripura and Karnataka.

The network of countrywide science exhibitions for children was more expanded this year than in previous years. This provided opportunity for a much larger number of children in the country to demonstrate their scientific abilities particularly those in the backward and tribal areas of the country.

Evaluation of Participants' Responses

An attempt was made to evaluate the participants' reactions on the National Science Exhibition. Three methods were used to have the participants express their viewpoints on various aspects of the exhibition. These involved the following:

1. The copies of questionnaire were distributed among the participants, both teachers and students, and 98 students responded to these.
2. All participants were also requested to prepare essays on one or more of the topics on various aspects of science exhibition. These were :
   (a) How I prepared my exhibit ?
   (b) An ideal national science exhibition ?
   (c) The role of teacher in exhibit preparation.
   (d) What I learnt from the science exhibition ?
   (e) How are science exhibitions helpful in science education ?

A total of 55 essays were received and the selected essays are being published in this issue of *School Science*.

3. In addition to the informal discussions with the participating teachers formal discussions were also held and they were asked to comment on the existing facilities and also to suggest ways and means to improve such exhibitions in future.

From these studies it appeared that over 80 per cent of the students were informed about the existence of the National Science Exhibition through their teachers and only about 15 per cent had prior knowledge of such an exhibition being an annual feature. Over 90 per cent of the student participants had this one as their first experience of the NSE and about half of these had not participated in any science exhibition in their respective states, districts or schools either.

In response to a question about how much time was required for the preparation of the write-ups and the exhibits in final shape about 50 per cent students indicated that one to three days were enough to prepare the write-up, only about 25 per cent required more than a week. As for the preparation of exhibits about

42 per cent could do it in less than a week's time, about 38 per cent required one-two weeks and 20 per cent needed two weeks or more.

Our major theme area "Human Ecology" seemed to be the most favoured pavilion in regard to exhibiting most interesting, creative and informative displays in the eyes of the participants. "Automation", "Human Disease", "Communications and Transport" were some of the other favourite areas. We also wished to assess the popularity and utility of the cultural evenings and scientific talks. About 50 per cent of the participating students felt that there should be not more than one or two cultural programmes during the exhibition but about 20 per cent wanted it every evening. The rest favoured it every alternate day. The reaction to scientific lectures remained rather undefined as about 25 per cent of the participants wanted one informative lecture everyday and pointed to the desirability of a lecture in relation to each exhibit-area. About the same proportion of students wanted such lectures to be kept at minimum of one or two. Other responses showed preference for lectures between three or eight in number and some favoured one lecture each in Biology, Chemistry Physics and Mathematics.

It was desired to know the nature of handout and souvenirs that the participants favoured. A very clear signal came in favour of a booklet which gave detailed account of each of the exhibited item. Only a few wished to get good science books or photographs of eminent scientists.

Almost all the students who responded to the questionnaire desired that the best exhibit in each of the areas he rewarded and majority of them favoured a special certificate of merit or a medal as the award. Some, indeed, wished to get cash prizes or books.

About the duration of the exhibition some 40 per cent favoured the existing pattern and about the same percentage favoured reduction to seven days only. Of the remaining only 5 per cent wanted it for a period of five days or less and 15 per cent favoured 15 days or more.

We also wished to assess the most inadequate factor of this year's exhibition. About 30 per cent complained about the space for exhibit being insufficient, 25 per cent indicated the inadequacy of the drinking water, 15 per cent complained about the toilet facilities and 10 per cent about the food in the canteen.

About 20 per cent gratified the organisers by expressing their full satisfaction.

A few of the interesting and worth considering suggestions either on the questionnaire, in casual conversation and in the discussions with teachers were as follows :

1. The exhibits should be widely televised and broadcast on the national TV and radio networks for the benefit of the children throughout the nation.
2. There should be more than one national Science Exhibition and at different places in the country every year.
3. Network of science exhibitions should be more elaborate.
4. Encouragement and support to outstation schools to visit the NSE should be provided.
5. The schools should have their visitors prepare a report of their visits.
6. The popular lectures should be printed, compiled and distributed to participants.
7. The number of participating schools should be larger.
8. The visitors of the exhibition should also express their views through questionnaires.
9. Efforts should be made to raise the standard of exhibits.
10. A scientific store should open its stall in the exhibition and supply the items required by the participants.
11. Needy schools in backward areas of the country should be given some financial assistance to prepare exhibits.
12. At least two students should be allowed to accompany each exhibits.

Shri Fakhruddin Ali Ahmed, President, and Smt. Indira Gandhi, Prime Minister, are seen talking to the young participants at the National Science Exhibition.

Prof. Nurul Hasan, Minister for Education and Social Welfare, and Prof. Rais Ahmed, Director, NCERT, at the exhibition.

Dr. Karan Singh, Minister for Health and Family Planning, is also an eager participant.

The NSE Participants' Impressions

HOW SCIENCE EXHIBITIONS ARE HELPFUL IN SCIENCE EDUCATION

The young students and their teachers, who participated in the National Science Exhibition 1975, had been asked to record their impressions, which they did sitting at the exhibition site. Three of those write-ups are reproduced below. We have not spoilt their spontaneous writings by 'professional editing'. They appear exactly as their authors wrote them.

—Editor

A SCIENCE EXHIBITION is a cooperative enterprise. It provides an occasion to learn from one another's experience and thinking. It helps in the improvement of science education, and its dissemination as well as in the promotion of creativety. It gives us a feel of excitement, the zest and dedication of the young participants. It provides more pleasant and heartening experience.

The purpose of science education is to develop certain scientific disciplines or attitudes towards their daily life, training in scientific method, development of moral value, making the society more civilized, development of mental and manual abilities and skills as well as development of motor skills as interest, appreciation and attitudes. Science exhibition helps in the achievement of the above goals of science education. It is to encourage initiative, creativity and Innovation. Kothari Commission has emphasized on the improvement of science education as "If science is poorly taught and badly learnt, it is more than burdening the mind with dead information and it would degenerate into a new superistition". To learn science is to do science.

There is tremendous growth in the scientific knowledge and science has entered in our daily life and activities so much that our existence would become impossible without it. All our activities are controlled and fashioned by science.

A child is by nature curious to find out new things. When he is successful it gives him pleasure, emotional stability and self-satisfaction. Science exhibition provides the biggest opportunity for this.

It is the science exhibition which promotes effective use of easily available materials, simple tools and application of fundamental principles of science to make it better taught, better appreciated and better understood. Through science exhibition, science is made a significant element of our culture, because it provides an occasion for cooperative effort and an opportunity to learn from one another's experience, students and teachers together. It reinforces initiative, innovation and creativity. The rapid advancement of science and technology and the increasing need for Scientists and technologists have made it all the more important that science is to be made more and more popular by organizing science exhibitions, not only on national level but also on state and district levels, so that it may fulfil the needs and aspirations of the people. Through science exhibition we can promote public awareness and appreciation of science.

One can do a lot of interesting science with readily available materials and appliances in homes, markets and forms, etc. The science exhibition can be made more effective by considerable planning and preparatory work, cooperation of schools and colleges and research institutions and hard work.

To remove poverty and unemployment from the nation, scientific and technological knowledge is to be disseminated in children, adolescents and the youth. The science exhibition provides the biggest opportunity for this, because it helps the nation in the following way.

1. Pupils become self-dependent, self-reliant and self-confident through activity.
2. The child becomes trained to solve any social problem scientifically.
3. Habit of industry and hardwork are encouraged.
4. It promotes science education, creativity and dissemination of scientific and technological knowledge.
5. It promotes public awareness and appreciation of science.
6. It promotes the feeling of cooperation and brotherhood and to learn from one another's experience, student's and teacher's together.
7. It provides opportunity to make innovations and improvisations to avoid the poor use of expensive apparatus.
8. It makes the science popular, essential for the progress of a nation.
9. It helps in providing functional information of facts and their understanding, development of instrumental skills, problem-solving skills, attitudes, habit of appreciation and interest.
10. It cultivates the qualities of personality, character and leadership, which are essential to a good scientist.
11. It promotes understanding of man and his environment—physical, social and economic.
12. It develops interest in them for taking science as a future course of study.

If we want to develop the qualities of ernest devotion, sincere dedication and profound scholarship among the young scientists and technologists of India, it is basically essential o1 bring some revolutionary changes in the science education and more emphasis should be laid on their hundred per cent active participation in new fields of science; so that they can appreciate science as a movement and as an instrument of social transformation. Science is to be linked with productivity as it is the need of the day : science exhibitions certainly can help in this respect.

I am sure that science exhibition encourages children to work on their own, to meet their own difficulties, to enjoy making the apparatus work and finding things out for themselves. It can help lazy and slow children also to learn and to join increasing acquaintance with concepts and instruments. Here, the pupil learns not simply by doing, but by observing the exhibits of others and the discussions.

Now, I conclude, that science exhibition promotes an ever-deepening understanding of basic principles, develops problem-solving and analytical skills and the ability to apply them to the problems of the material environment and social-living. It also promotes the spirit of enquiry and experimentation and thus it becomes an important and valuable source of developing scientific outlook/attitude towards their daily and national life and culture. We have to make science an integral part of our cultural and spiritual heritage.

P. R. VERMA
Postgraduate Teacher in Physics
Kendriya Vidyalaya
Hindon, U.P.
Air force Station,
Ghaziabad

AN IDEAL NATIONAL SCIENCE EXHIBITION

THE REQUISITES of an exhibition of the national level are not often fulfilled in the National Science Exhibition. Personal experience, thus necessitates one to brood over an ideal National Science Exhibition.

The first and perhaps a very important part of the exhibition is the preparation of the project. For an ideal exhibition, it is essential that it must be prepared with great caution and decoratively. This can be accounted for only if the students are given proper guidance and adequate time to prepare the exhibits.

As for the past two years, some projects have been far below standards and a number of them have been re-exhibited for several years. These things, unfit for an exhibition of the national calibre must be eradicated with the help of the organizers. All participants must be interviewed and the exhibits must be selected only after rigorous examination and consideration.

Once the final list of entrants, who have been selected, has been prepared and the participants are intimated properly, adequate arrangements of space, food, water and transport must be made. There should be enough space for each exhibit to be accommodated in its respective pavilion. Proper arrangements of hygienic food and water must be made for the participants, even those residing in Delhi if they so require. The Delhi Transport Corporation must be requested to run special bus services to and from the exhibition grounds in order to convenience the local participants and numerous visitors.

Now the exhibits must be put up in attractive manner so as to stimulate scientific interests and scientific skills in the visitors, notably in the youngsters. Projects accomplishing such ideals will be serving the nation in a unique manner.

The exhibits must carry a high level of information and should be greatly educative, not only to a scientific person but also to those who possess no such scientific intellect. This job must be handled properly by the participants who accompany each project. Charts and other informative material must be compulsorily put up along with each project.

The National Science Exhibition must prove to be an invaluable tool in providing science education to science students. The participants must enlighten the science students in a logical order, about the scientific principles involved in their project. The basic knowledge of science in young science students must be used as a base to build in their minds a network of science within their grasp.

The projects which involve the application of the same in daily life and for the service of man must be placed in a high order. They must be given due encouragement and proper guidance.

An ideal National Science Exhibition must educate the young enthusiasts through projects, but also through lectures (accompanied with demonstrations) and educative films. All participants must be compelled to attend these.

A National Science Exhibition of a high order must also promote national feeling of unity and brotherhood through 'cultural evenings'. Such functions must involve the mixing of participants from the various states.

Last of all, the exhibits which are deserving should be duly rewarded. The efforts of the participants must be recognized properly and prizes for best exhibits must be given.

If a National Science Exhibition achieves all the mentioned objectives it will be fit to be called an IDEAL NATIONAL SCIENCE EXHIBITION and such an exhibition will prove to be of high value to science and the nation.

SUNIL MATHUR
St. Xavier's School
4, Raj Niwas Marg
Civil lines
Delhi

HOW DID I PREPARE MY EXHIBITS ?

WE WERE GOING through a gruelling class of arithmetic when we were called out and informed about the forthcoming All-India

Science Exhibition. Promptly after school we met and sat and discussed with our teachers. Although ours is a co-educational institution we were just girls on this particular project as it was being prepared by the Domestic Science Department and one can hardly expect boys to take part. Anyway, the conclusion we arrived at after a long discussion was that (a) we would prepare something to do with women and science as it was Women's International Year; (b) something to do with some management, and (c) something original and unusual and interesting. There was another discussion and we finally decided our project.

Then began a flurry of activity and utter confusion that usually prevails when everybody tries to do something and only succeeds in getting into someone else's way. How that month went past is a miracle in itself. The project was divided into three parts. Firstly, about the outgoing Indian woman, the role she plays at home as a mother and wife, and the nutrition and dietary requirements for the family for a day according to a balanced diet. Now we wanted to depict the outgoing Indian woman and her role at home in an unusual manner, not by the normal charts and diagrams. We thought that since we were going to show her at home and the home was going to be the centre of activity, why not make a model of a home. So, we got the architect's diagrams of our Principal's house which had recently been built on the school premises. We made a copy of the diagram to a smaller scale. Next, cork sheets were bought and cut to the same measurements and that was how we built the house model. We painted it and placed it on a high level. Now came the most interesting part of it. The Indian woman's role at home was going to be depicted photographically, with models from school! Two girls took the photographs in our Principal's house while, she, our teacher, and three children modelled a day's activities. These photographs were placed on a disc and touched up with photographic colours. The model of the house was placed in the centre. We mounted the disc on a wheel and now it could rotate!

Now we went on to the dietary requirements of the family. We drew up balanced diet sheets for each member depicting the proximal principal requirements and the calories. Next we mounted oval-shaped photographs of the family on a stand and with coloured cords showed their nutritional requirements. This we did in a very interesting manner. We made individual trays containing samples of uncooked food according to the balanced diet sheets. To these we led the coloured cords from the photograph of each family member. It really looked very neat and interesting and I remember we were all hoping it would be appreciated as much. This led to the completion of the first part of our project and we went to the next.

This part of our project dealt with diseases. That is to say, the common diseases prevalent amongst children. Again, we wanted to be original and discarded the idea of photographs and diagrams. We prepared charts showing the signs, symptoms, carriers, incubation period and preventive measurers of the most commonly prevailing diseases; mumps, chickenpox, measles, conjunctivities and common cold. For a long time we discussed and debated but to no avail. We just couldn't think of anything original. And then finally we hit upon an idea. We made clay models depicting each disease. Over this we poured a paste of plaster of paris. After this had set we poured another lot of plaster of paris. When this had set, with hammer and chisel we started chipping at the outer mould, and removed the clay. And lo and behold! We had life-like models depicting each disease. These we painted and they really looked realistic.

We now went on to the last phase of the project or should I say the first. For this, we felt was what would attract people in an exhibition of puppet show! Being from the domestic science group, we needed no ideas for making puppets, we had them all! So after much healthy quarrels and debating we decided on making a ceatin type of puppets. This was most enjoyable. With sock and cardboard and cloth and tiny clothes our puppets were ready. We set up a little stage and added colour to the scene with bright curtains and fancy ribbons. We made up a short conversational story about cleanliness, food and the type of food one should eat. The puppets were to be manipulated by two girls who would speak the conversation.

Our project was complete. But the interest and labour we put in will live on in our minds. In fact, I think we will always remember this exhibition not only because it was so well organized and that we enjoyed taking part in it but because it was so interesting to formulate and work on your own project and have it appreciated at the exhibition. This experience will be everlasting and uppermost in our memory. □

GEETA MATHRANI
Bal Bharti Air Force School

Scientific Terms

Used in This Issue

Antibiotic : Chemical substance elaborated by living organisms, usually by the micro-organisms, which diffuses into its surroundings and is toxic there to individuals of other species. Several such substances are increasingly being used as medicine to combat various infective diseases. Penicillin, the first discovered antibiotic from several species of *penicillium* is highly toxic towards the gram positive bacteria, e.g. *Streptococcus* sp. A large number of other antibiotics have since been used successfully against many virulent infections.

Antigen : Substance (usually a carbohydrate or protein) foreign to the body, which are capable of stimulating antibody formation. Antibody formation is a natural protective device of the animal organic system.

A or °A° : Angstrom; unit of length used to measure extremely minute objects and/or small distances. One angstrom is ten millionth part of a millimeter or ten thousandth part of a micron. ($1\mathring{A}=1\times10^{-10}$ metres).

Lysosome : Submicroscopic membrane bounded cell organelle which can be demonstrated by the electron microscope. These are found in the cytoplasm of the animal cell. They contain hydrolytic enzymes, which when liberated in the injured cells assist in the digestion and removal of dead cells. They are also believed to be involved in autolysis and selective destruction of tissues during metamorphosis and other developmental processes. Similar structure have also been observed in plant cells.

Mesosphere : (1) The region of the Earth's atmosphere between stratosphere and thermosphere. (2) The region of the Earth's atmosphere between stratosphere and exosphere.

Stratopause : The boundary between the stratosphere and mesosphere.

Stratosphere : A layer of Earth's atmosphere above the troposphere.

Tropopause : The boundary between the troposphere and stratosphere.

Troposphere : The lower part of the Earth's atmosphere (nearest to the Earth's surface).